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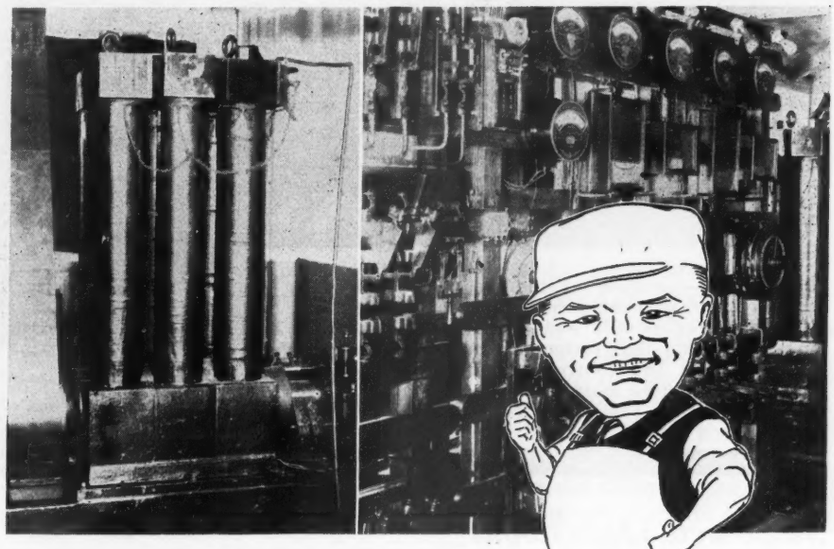
Here's an Old Timer Installed 43 Years Ago

with its old switchboard dressed up with some later-day instruments



HERE is a generator that takes you back to the beginnings of generator design in Thomas A. Edison's machine shop at Menlo Park, N. J., in the late '70's. This particular machine and three others like it are still in operation in the plant of the Grinnell Manufacturing Corporation at New Bedford, Mass., where they were installed in 1882, about 43 years ago. Certainly the designers built better than they knew, for these machines have worn themselves out twice over, according to the modern rule of applying depreciation on an estimated useful life of 20 years. But still they carry the lighting load and appear to be able to do so for some time to come.

From the standpoint of maintenance it is interesting to know that each machine during the past 43 years has had one new commutator and with the exception of repairing one or two bearings and renewing the brushes, no other repairs have been found necessary.

As will be noted, they are driven by almost vertical belting from a line-shaft, an arrangement that would not be recommended today for so-called mechanical reasons, but this drive and these generators have not and do not perform according to opinions or modern engineering ideas; they just keep on going as good machines might be expected to operate, with no need for excuses or apologies of any nature on the part of the designer or the operator. It would be a happy day in many a plant if some modern equipment would perform in like manner. But in the old days when these generators were built the idea was to produce the best generator possible, contrasted with the idea often found today of building the best design that can be made cheap and stand a show when the buyer sharpens his pencil and sets out to see just how little he needs to pay to get the thing, on which he has asked all the Toms, Dicks and Harrys in the manufacturing business to bid, delivered in his plant. When he gets it and it operates he is usually satisfied, but if it fails in any respect the abuse that the maker gets in letters and conversation is like a drama with a rough villain and no plot. But this angle of modern buying I do not intend to discuss now.

In the old Edison machine works at Menlo Park the first generators built in 1880 were called "Z" dynamos. In re-designing these "Z" machines a few years later they were enlarged by adding an extra field magnet and lengthening the armature and the base. These redesigned machines were called "L" dynamos. The "K" design came along about the same time, and is the design shown in the accompanying illustration, still larger than the others, with three field magnets all of the same size as in the "Z" machine, but with a longer armature and base. These machines embody Mr. Edison's original conception of a dynamo with an armature of very low resistance as compared with the total resistance of the machine.

The old switchboard, also shown in the illustration above, was installed at the same time as the generators. On it can be seen an old-type field rheostat which was used for all three generators. Much difficulty was experienced in getting the three machines to operate in parallel, and to do this the brushes had to be continually adjusted. But this is no fault peculiar to these machines; no doubt there are many who read this that can tell some interesting tales about getting some modern machines to divide their loads equally.

Some of you men may wonder why I have dug up this old stuff to talk about, and to you I will simply say this: If you will visit one of these old installations and get a good understanding of the abuse these old machines have stood, you will have more respect for good design in machines, and when you are called upon to buy equipment in the future you will not compare equivalent machines on the basis of dollars per pound. Design ability and successful operation are not rated that way. To those of you who have had years of experience with some of the good designs that have been and still are made, I have nothing to say. You know the whole story and could probably write a good article some day around your experiences. By the way, this would be well worth your while and INDUSTRIAL ENGINEER would be interested in publishing it if you make it good and full of details. In case you happen to have an old-timer in your plant, just drop me a line and I'll help you to frame up an article that will be so good that the Editors will be glad to print it.

Practical Pete

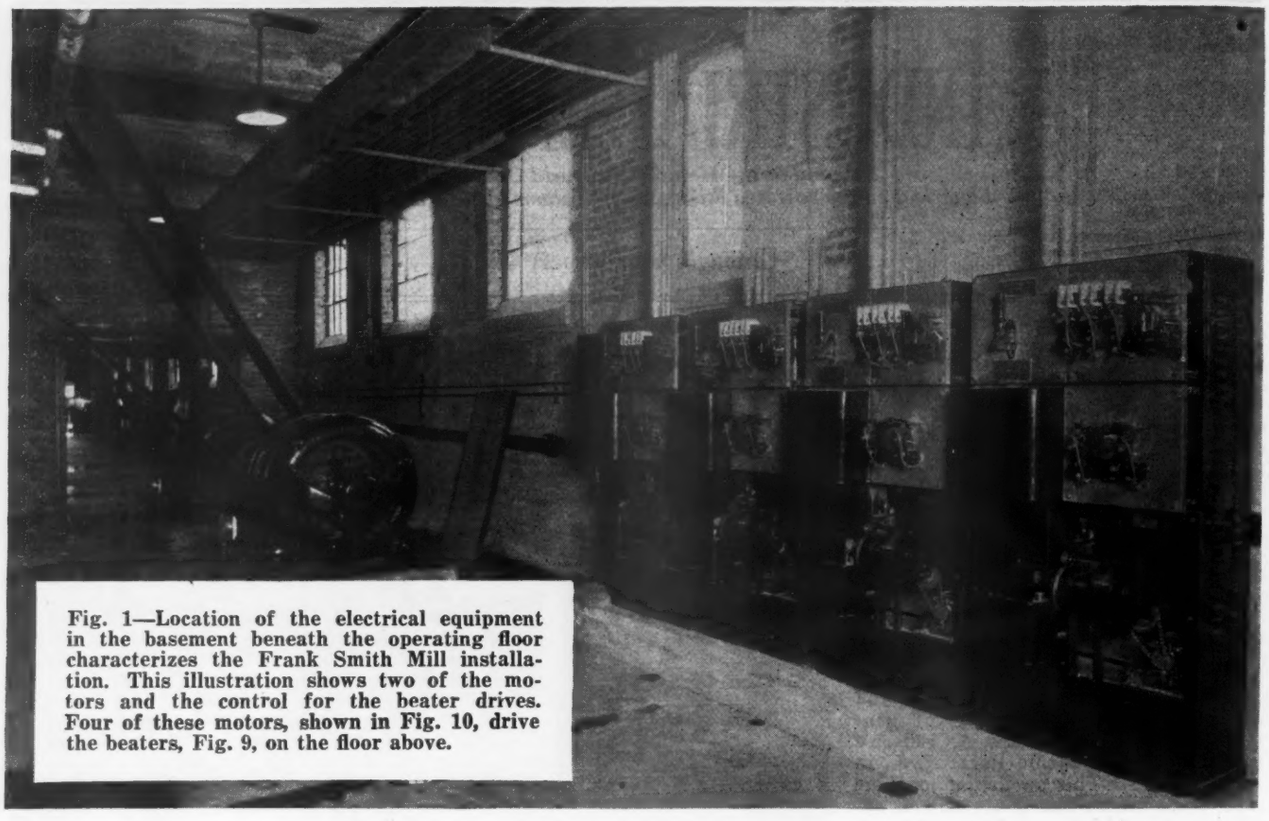


Fig. 1—Location of the electrical equipment in the basement beneath the operating floor characterizes the Frank Smith Mill installation. This illustration shows two of the motors and the control for the beater drives. Four of these motors, shown in Fig. 10, drive the beaters, Fig. 9, on the floor above.

Some new ideas about

Paper Mill Power Drive and Motor Control Layout

that were applied in a new mill to the installation of power service equipment, including the types of motors, methods of control, and kinds of drives used

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SOME novel and interesting features of design and layout have been embodied in the distribution, application, and control of power service in the new Frank Smith mill of the Paul A. Sorg Paper Co., at Middletown, Ohio. Naturally, continuous service with few delays was uppermost in the minds of the men laying out the drive applications. However, there were four other thoughts behind the installation. They are: (1) Remote-controlled, automatic operation throughout, thereby permitting the use of cheaper, unskilled labor as well as giving greater protection to the equipment involved. (2) Location of electrical equipment so as to give the greatest measure of protection from corrosive elements common to paper mills. (3) Convenience of making changes, re-arrangements, and expansions. (4) Ease of maintenance and repair. These factors lay behind the selection and installation not only of the electrical equipment, but also of the mechanical elements such as belts, gears, couplings, clutches and the like, which are also a very decided factor in the success or failure of a drive application.

The Frank Smith mill was built with the idea of producing paper specialties; all grades of paper are intended to be produced, from tissue to high-grade bond paper. This mill does not produce paper pulp. The process starts with shredding of the raw material, which is then put through the bleaching process, through the beaters and Jordan engines and into the machine room, where it is converted into the finished product.

The front portion of the mill building is known as the bleach house, the middle portion as the beater room and the rear as the machine room. A basement extends under the entire building and the bleach house and beater room consist of more than one floor, although practically all of the paper making equipment is either on the ground floor or in the basement.

To protect the electrical equipment from the water and corrosive elements common to paper mills, as many of the larger motors as possible were located in the basement. Out of a total of 66 motors it was found possible to place 36 of them in the basement. The basement is clean and dry and gives plenty of room around the motors for inspection, maintenance and repair. Also, this arrangement gives more free space around the equipment on the floor above.

Automatic or push-button control is used throughout, which permitted the location of the control panels at any place desired. However, the panels are grouped in three locations in the basement: one group consists of the controllers for the bleach house (shown in Figs. 5

and 6); the second group is for the beater motors (shown in Fig. 1), and the third group consists of the machine room controllers, a portion of which are shown in Fig. 11.

Centralizing the controllers and placing the majority of the motors in the basement or on the floor above greatly simplified the distribution system. The average load taken by this mill is approximately 1,500 kw. A large share of this load is supplied from the local public utility, the balance being taken by the power house in one of the nearby mills of the company. Power is brought in at 13,200 volts and stepped down by transformers to 440 volts, at which voltage it is distributed throughout the mill. There is also a small amount of 230-volt, d.c., power used. Feeders go from a seven-panel switchboard located in a corner of the rear end of the main floor, through the floor to a conduit system that is carried on the ceiling of the basement. This system is carried along the ceiling so as to reach the three groups of control panels. Connecting conduit was easily dropped to each group of control panels; likewise, conduit was readily carried down the wall or the building columns to motors in the basement. The motors on the floor above were easily reached by conduit through the floor. This arrangement of conduit and controllers used a minimum amount of conduit, did away with the need of distribution boxes, and kept the conduit accessible so that alterations or repairs could be easily made.

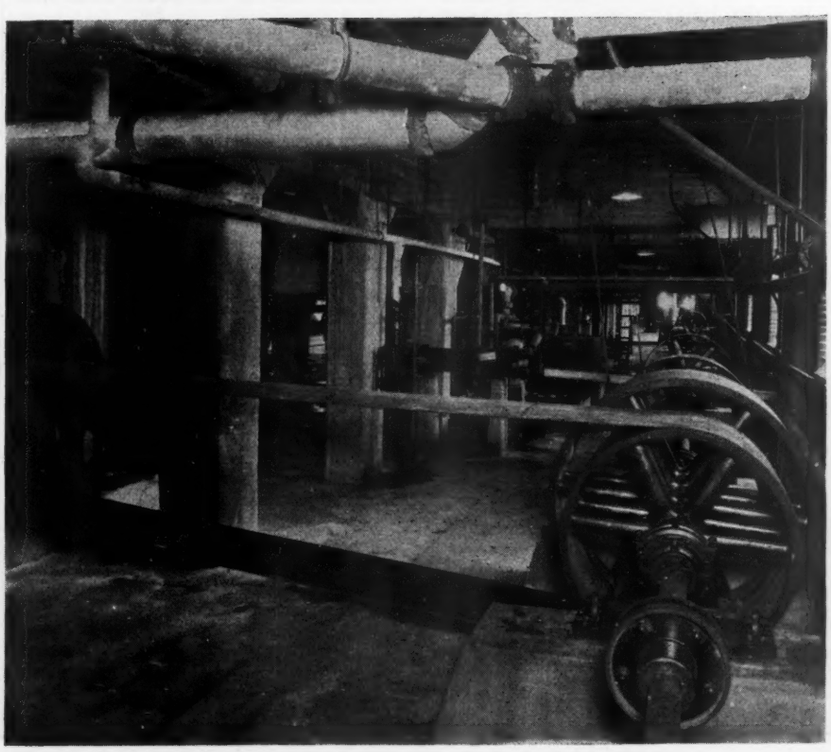
Centralizing the controllers in this manner would result in a large number of conduits coming together over each group of controllers and due to crossovers and interconnections, the result would be an awkward installation. To eliminate this, pull boxes were installed over each group of control panels and also at such other points where it would otherwise be necessary to group a large number of conduits.

The pull boxes were made of sheet iron fastened to angle-iron frames, as shown in Fig. 11. The boxes are hung from the ceiling. Sections of one side of the boxes are hinged at the top as shown in Fig. 11, thereby permitting inspection. Crosswise racks are placed in the boxes so as to permit carrying the wires in three layers, two layers being supported by racks while the third layer lies on the bottom of the box.

One disadvantage of this system of distribution lay in the fact that it would be hard to locate the wires for a given motor and control unless some system of identification were used. This was overcome by the use of identification tags and colored wire. Tags were placed on the wires at the motor terminals, control panel terminals and also in the junction and pull boxes. Each motor was assigned a series of two or three letters; for instance SA represents No. 1 Bleacher motor in the bleach house. An additional letter is added to distinguish which circuit of this motor is involved, as P for primary or line, S for secondary, and C for control. In addition the phases are numbered 1, 2 and 3. Hence, a wire with a tag number SAP 2 indicates that it is the wire for the second phase of the line or primary side of the motor. The control wires that run from the push buttons to the panels are colored, the start wire being green, the stop wire red, and the common return wire black. Other colors are used for the meter wiring. In addition to this, a diagram was made showing the location of the conduit and the pull and junction boxes. This diagram also shows sections taken at the ends of the boxes where conduits enter and the wires in each conduit at the points where these sections are taken are marked with the same information as is put on the tags.

Fig. 2—A lineshaft running in ball-bearing pillow boxes is used on the variable-speed paper machine drive.

The seven sections of the paper machine are driven by the variable-speed, shunt-wound, Crocker-Wheeler motor shown at the left. The lineshaft runs in ball-bearing pillow boxes mounted on concrete pedestals. The control for this motor is shown in Fig. 11.



In the bleach house there are 23 motors ranging in size from 1½ hp. to 100 hp. A list of these motors, together with the equipment driven, is shown in Table I. As can be seen from the list the drives required are for pumps, fans, agitators, filters and the like. All of the machines have individual drive because simultaneous operation of all of them is not essential for continuous production. Direct drive through flexible couplings is used for the higher speed applications while belt drive is used for those of slower speed. In case of very slow speed drives, a back-geared motor is belted to the machine, as shown in Figs. 4 and 7.

As was stated earlier in the article, the control panels for the motors in the bleach house are grouped together at one point. Front and rear views of this control board are shown in Figs. 5 and 6. Allen-Bradley automatic primary-resistance type controllers, across-the-line type starters, and secondary-resistance type starters for wound-rotor motors are used. Overload protection is obtained through circuit breakers or overload relays on each panel. The resistors are of

the compression type made by the Allen-Bradley Co. Since these resistors are in the form of long tubes they could be mounted directly behind the panels without preventing access to the wiring on the rear of the panels, as is shown in Fig. 6. This gave a very compact arrangement. The illustration also shows the terminal boards at the top and center of the panels.

The eight beaters in the beater room are driven by five motors located in the basement. Ordinarily four beaters are required for normal operation; so four beaters are belted to one lineshaft which is also located on the floor of the basement beneath the beater floor. The remaining four beaters have individual drives and are used to take care of the peaks in production and also act as spare equipment in case any of those in the group drive have to be shut down.

Because of the high starting torque required, wound-rotor motors are used for the individually-driven beaters. These are Crocker-Wheeler motors rated at 85 hp., 385 r.p.m., and are belted to the beaters. These motors are shown in Figs. 9 and 10.

From Fig. 9 it will be seen that the beaters are arranged four in a line. The group shown contains the ones that are individually driven. Immediately to the left is a second row of four beaters, which are driven from a lineshaft. This lineshaft is placed on the floor of the basement directly below the driving pulleys of this group of beaters. The lineshaft is coupled directly to an Electric Machinery Co.'s synchronous motor rated at 265 hp., 450 r.p.m., as is shown in Fig. 12. The use of the synchronous motor for this application counterbalances the comparatively poorer power factor of the wound-rotor motors driving the other beaters. Also it aids in improving the power factor of the entire plant.

Fig. 3—Push-button control stations are located at convenient points adjacent to the machines controlled.

Here are shown the push buttons for starting and stopping the synchronous motors driving the Jordan engines; also, the stop button for the constant-speed drive. The meters inside the cabinets are calibrated in horsepower and indicate the load on the motor which the push button controls.

The lineshaft is located in the basement and is directly under the driven pulleys of the beaters. It is supported on sleeve-bearing pillow blocks which are mounted on concrete pedestals. A belt wrapping and tightening device known as the Lenix Drive (made by F. L. Smidth & Co.) is used on each lineshaft pulley. This not only provides a means of independently disconnecting each beater in the group, but also permits operation with a short distance between centers of driving and driven pulleys. In addition, the Lenix Drive insures that sufficient area of the driving pulley is in contact with the belt going to the much larger driven pulley on the beater directly overhead.

Table I—Drive Data of the Equipment Used in Bleach House

Machine Driven	Type	Rating Hp.	R. P. M.	Motor Mfg.	Type of Control	Control Mfg.	Method of Drive
No. 1 Bleacher	Wound rotor	50	860	Allis-Chalmers	Automatic	Allen-Bradley	Belt
No. 2 Bleacher	Wound rotor	50	860	Allis-Chalmers	Automatic	Allen-Bradley	Belt
No. 3 Bleacher	Wound rotor	50	860	Allis-Chalmers	Automatic	Allen-Bradley	Belt
Shredder	Wound rotor	100	1,165	Allis-Chalmers	Automatic	Allen-Bradley	Flex. coupling
Vacuum pump	Squir. cage	40	860	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Belt
Plunger stuff pump	Squir. cage	7.5	570	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Belt
Filter pump	Squir. cage	30	1,155	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Flex. coupling
Bleached stock pump	Squir. cage	20	860	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Flex. coupling
Filter overflow pump	Squir. cage	3	1,140	Allis-Chalmers	Across-the-line	Allen-Bradley	Flex. coupling
Filter drive	Squir. cage	3	1,140	Allis-Chalmers	Across-the-line	Allen-Bradley	Reduction gear
Washer water pump	Squir. cage	20	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Flex. coupling
Agitator bleach chest	Squir. cage	15	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Gear and belt
Agitator bleach chest	Squir. cage	15	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Gear and belt
Agitator bleach chest	Squir. cage	15	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Gear and belt
Agitator filter chest	Squir. cage	15	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Gear and belt
Vacuum pump	Squir. cage	10	1,150	Allis-Chalmers	Man. compensator	Allis-Chalmers	Back gear
Alum tank agitator	Squir. cage	3	1,140	Allis-Chalmers	Across-the-line	Allen-Bradley	Gear and belt
Air compressor	Squir. cage	1.5	1,750	Robbins & Myers	Across-the-line	Allen-Bradley	Belt
Shredder conveyor	Squir. cage	3	1,140	Allis-Chalmers		Allen-Bradley	Gear and belt
Shredder blower	Squir. cage	30	685	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Flex. coupling
Two elevators	Squir. cage			Warner Elev. Co.			Direct
Heater	Squir. cage	3	1,140	Allis-Chalmers	Across-the-line	Allen-Bradley	Belt

Table II—Drive Data of the Equipment Used in Beater Room and Pump House

Machine Driven	Type	Rating Hp.	R. P. M.	Motor Mfg.	Type of Control	Control Mfg.	Method of Drive
No. 1 Beater	Wound rotor	85	385	Crocker-Wheeler	Automatic	Allen-Bradley	Belt
No. 2 Beater	Wound rotor	85	385	Crocker-Wheeler	Automatic	Allen-Bradley	Belt
No. 3 Beater	Wound rotor	85	385	Crocker-Wheeler	Automatic	Allen-Bradley	Belt
No. 4 Beater	Wound rotor	85	385	Crocker-Wheeler	Automatic	Allen-Bradley	Belt
Nos. 5 to 8 Beaters	Synchronous	265	450	Elec. Machine Co.	Automatic	Elec. Mach. Co.	Direct
Heater	Squir. cage	2	1,135	Allis-Chalmers	Across-the-line	Allen-Bradley	Belt
No. 1 Deep well pump	Squir. cage	40	1,150	Allis-Chalmers	Man. compensator	Allis-Chalmers	Direct
No. 2 Deep well pump	Squir. cage	40	1,150	Allis-Chalmers	Man. compensator	Allis-Chalmers	Direct
Heater	Squir. cage	3	1,140	Allis-Chalmers	Across-the-line	Allen-Bradley	Belt

All motors are for 440-volt, three-phase service.

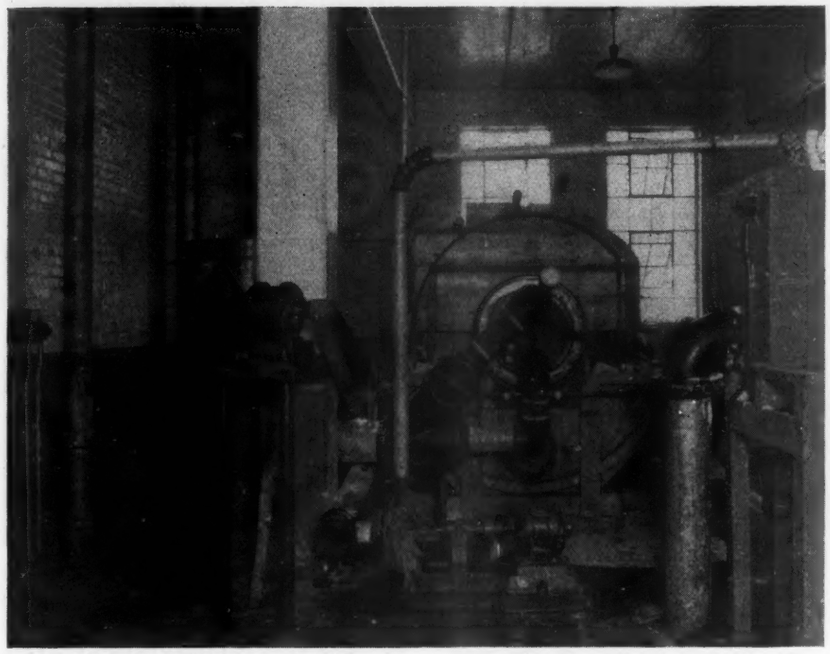


Fig. 4—Drive installations used in the bleach house.

The back-geared motor at the left drives the shredder chest through a belt. In the center is a small pump directly connected to a motor through a flexible coupling. The push buttons for these two motors, as well as a third motor, are shown at the extreme left. The control panels for these motors are in the basement and are part of the group shown in Fig. 10.

When starting the synchronous motor, the counterweights on the Lenix Drives are raised, thereby permitting the belts to hang slack and causing the motor to start the lineshaft under no-load conditions. Electrical interlocks, controlled by the position of the counterweights on each Lenix Drive, are connected in series with the start button of the motor control so as to prevent starting the synchronous motor in case any of the Lenix Drive units have not been released.

Belts are used on all of the beater room drives as these provide a very economical method of connecting the driving pulleys of the lineshaft and motors with the driven pulleys on on the beaters on the floor above.

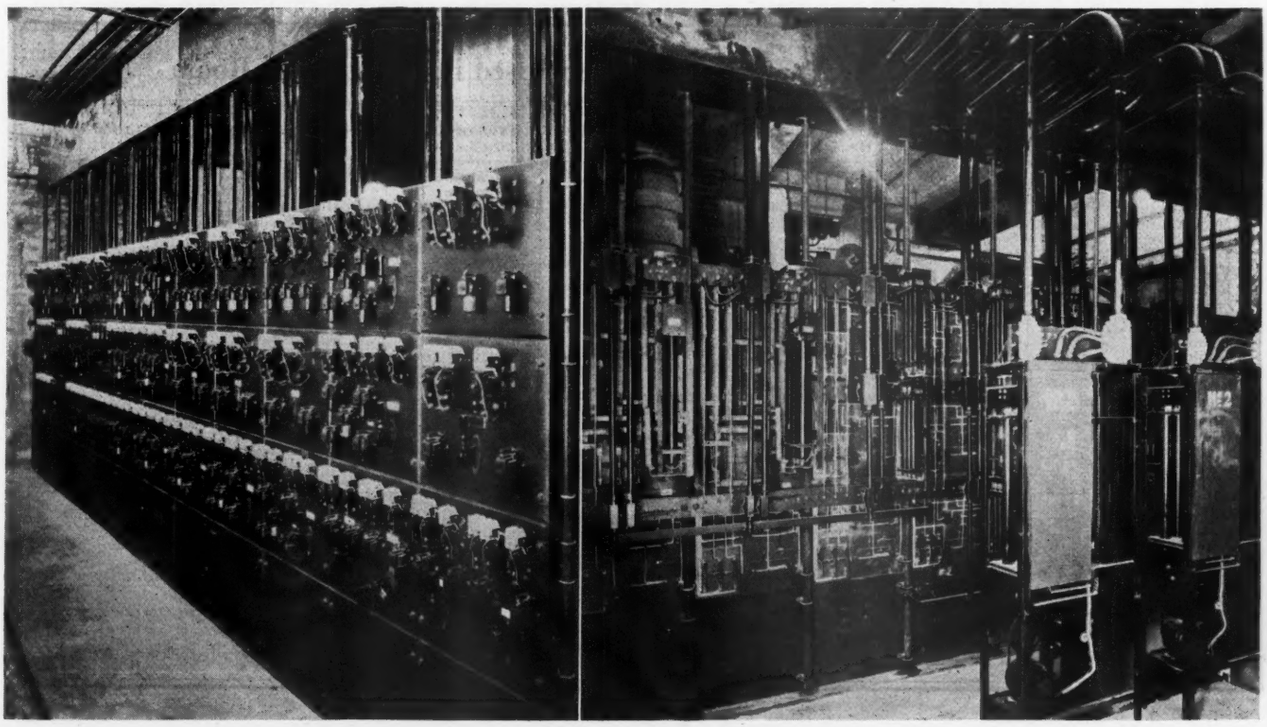
Figs. 5 and 6—Grouping of individual control panels at central locations is a feature of the control installation.

This control board is made up of Allen-Bradley across-the-line starters and automatic, primary-resistance starters. Fig. 6, right, shows the neat arrangement of resistors made possible through the use of compression-type tube resistors. The two controllers in the right foreground are current- and time-limit secondary resistance starters for the bleacher slip-ring motors.

The control for the synchronous motor is an Electric Machinery Co.'s push-button-operated automatic starter. This controller automatically starts the synchronous motor on reduced voltage, closes the field switch at the proper moment and then switches the motor to the full line voltage.

The starters for the wound-rotor motors are of unusual interest. They are shown in Fig. 1. The four controllers are mounted together in the basement, adjacent to the wound-rotor motors that they control, two of which can be seen at the left in the illustration just referred to. The controllers are the Allen-Bradley type J-3230 and provide both time-limit and current-limit acceleration of the motor. This type of controller uses compression-type resistors, which are placed in series with each phase of the rotor of the induction motor.

The operation of the controller is simple. Pushing the start button closes the primary switch, connecting the motor to the line. The closing of this switch also starts the pilot motor which is located at the



bottom of the control panel and is used for compressing the resistors. The pilot motor rotates a camshaft that compresses the resistors (connected in series with the rotor), until the wound-rotor motor starts. The current relay which is connected in series with the primary circuit and which is set for the maximum desired starting current, then governs the acceleration of the motor. If the primary current rises above the predetermined value for which the relay is adjusted, the latter will act to stop the pilot motor. However, as soon as the current is reduced, due to the acceleration of the motor, the relay will close and start the pilot motor again, thereby further compressing the resistors, which decreases the value of resistance in the secondary of the motor. This action is continued until the motor has been fully accelerated and the resistance short-circuited by a contactor on the panel.

The gearing of the pilot motor to the camshaft is so arranged that approximately 5 to 8 sec. are required to turn the camshaft from the full-resistance position to the lowest-resistance position, if the action is not interrupted by the series relay. The additional time required for bringing the motor to full speed is allowed for by this relay. Consequently, a definite minimum time for starting the motor is provided by the controller, which insures that no undue shock or strain is thrown upon the equipment during the starting period and if unusually high starting torque is required, current-limit acceleration takes care of the acceleration until the motor is thrown across the line.

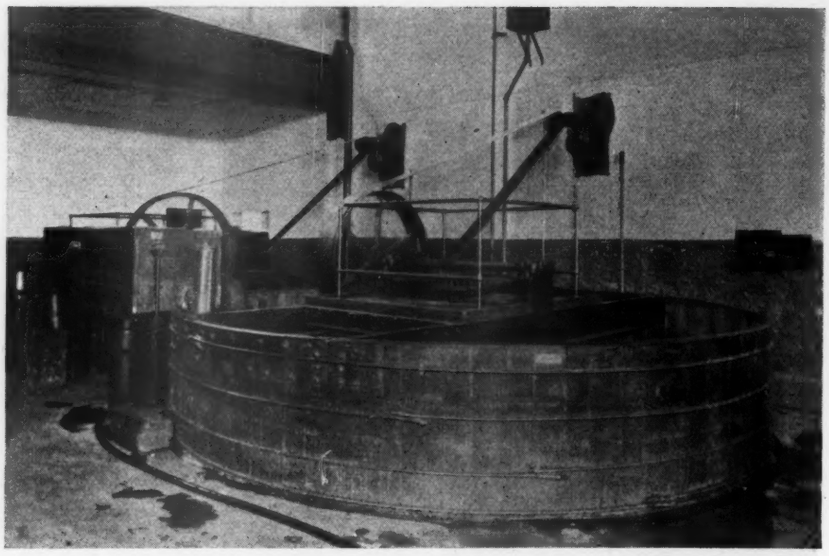


Fig. 7—Back-geared motors are belted to the stuff chests and to the agitators.
This permits mounting the 7½-hp. squirrel-cage motors on the wall, thereby keeping this equipment clean and dry.

Push buttons for starting and stopping these motors are located on the wall adjacent to each beater.

A wattmeter calibrated in horsepower is also located at each push-button control station, so that the operators can know the condition of the load on the individual motors, thereby enabling them to judge the quality of product being produced by the machines. The wattmeter and push-button stations are arranged in sheet-iron cabinets, one of which can be seen at the extreme right of Fig. 9. A close-up view of a similar control station can be seen in Fig. 3.

There are 34 power drives in the machine room and in the basement under it. It is in this room that the pulp is put through the Jordan engines for refining. It then passes on to the paper machine where the liquid paper stock or pulp is converted into paper.

Inasmuch as the load on the Jordan engines can be reduced as much as desired when starting, they are driven by synchronous motors which are directly connected thereto. The

Table III—Drive Data of the Equipment Used in the Machine Room

Machine Driven	Type	Rating Hp.	R. P. M.	Motor Mfg.	Type of Control	Control Mfg.	Method of Drive
No. 1 Jordan	Synchronous	200	360	Elect. Mach. Co.	Automatic	Elec. Con. & Mfg.	Direct
No. 2 Jordan	Synchronous	200	360	Elect. Mach. Co.	Automatic	Elec. Con. & Mfg.	Direct
No. 1 Agitator	Squir. cage	10	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Reduction gear
No. 2 Agitator	Squir. cage	10	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Reduction gear
Constant-speed drive	Squir. cage	125	585	Crocker-Wheeler		Allen-Bradley	Belt
Motor-generator	Synchronous	230	1,200	Crocker-Wheeler	Automatic	Allen-Bradley	Direct
Variable-speed machine	D. C.	200	600	Crocker-Wheeler		Allen-Bradley	Belt
Rewinder	D. C.	25	335/1,000	Crocker-Wheeler	Automatic	Allen-Bradley	Belt
Stuff pump	D. C.	7.5	300/600	Crocker-Wheeler	Automatic	Allen-Bradley	Belt
Stuff pump	Squir. cage	7.5	535	Elec. Con. & Mfg.	Compensator	Elect. Con. & Mfg.	Belt
Wire shake	D. C.	0.4	450/900	Crocker-Wheeler	Automatic	Allen-Bradley	Belt
Oil pump	D. C.	0.25	1,725	Western Electric	Safety switch	Square D	Direct
Oil pump	D. C.	0.25	1,725	Western Electric	Safety switch	Square D	Direct
Monorail crane	D. C.				Manual	ShephardC.&H.Co.	Gear
Consistency regulator	Single phase	0.1	1,750	Robbins & Myers			
Oil pump	Squir. cage	2	1,155	General Electric	Across-the-line	Allen-Bradley	Gear
Beater room pump	Squir. cage	25	1,740	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Flex. coupling
Machine pump	Squir. cage	25	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Flex. coupling
No. 3 Agitator	Squir. cage	7.5	850	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Speed reducer
Four heaters	Squir. cage	3	1,140	Allis-Chalmers	Across-the-line	Allen-Bradley	Belt
Four heaters	Squir. cage	2	1,135	Allis-Chalmers	Across-the-line	Allen-Bradley	Belt
Elevator	Squir. cage			Warner Elev. Co.			Flex. coupling
Seybold cutter	Squir. cage	7.5	1,140	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Belt
Water pump	Squir. cage	10	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Flex. coupling
Ventilating fan	Squir. cage	15	1,150	Allis-Chalmers	Compensator	Allis-Chalmers	Belt
Breast roll hoist	D. C.			General Electric			Direct

Direct-current motors are for 230-volt service.
All other motors are for 440-volt, three-phase service, except the single-phase motor, which is connected to the 110-volt supply.

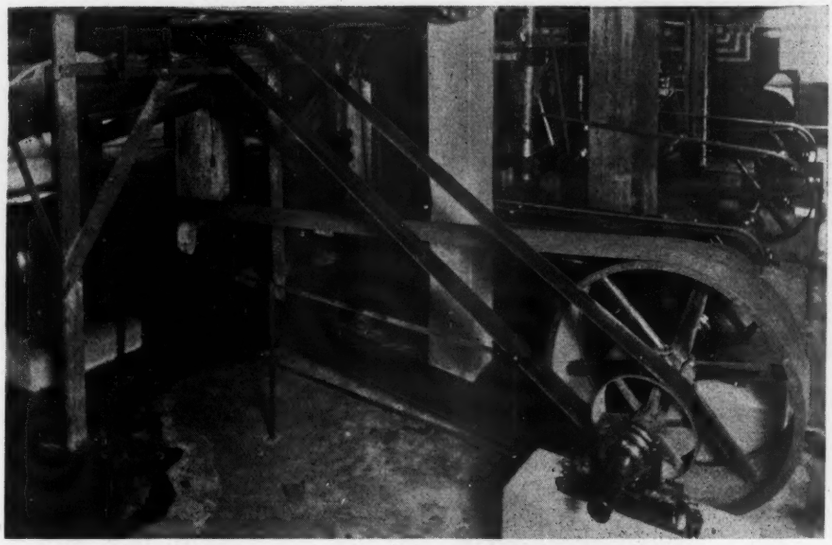


Fig. 8—Group drive is also used on the constant speed drive.
A Crocker-Wheeler, squirrel-cage, induction motor drives this lineshaft, which in turn drives a group of seven pumps used on the wet end of the machine.

two Jordans are driven by Electric Machinery Co. motors rated at 200 hp., 360 r.p.m. They are controlled by push-button-operated, automatic starters made by the Electric Controller and Mfg. Co. One of the Jordan engines together with the push-button control station is illustrated in Fig. 3.

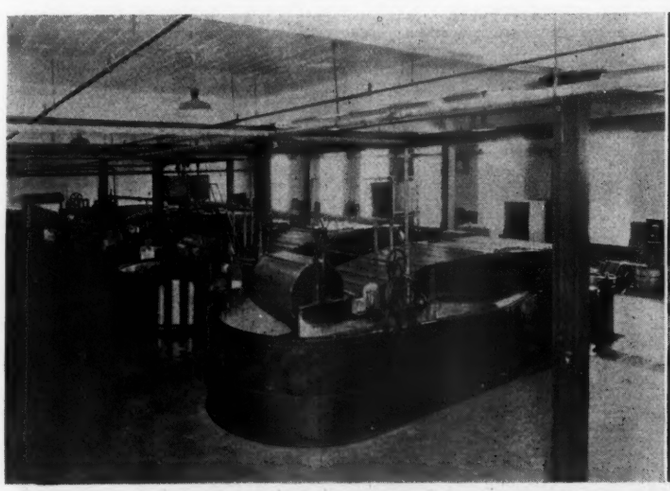
The main drives on the paper machine proper are the constant-speed drive and the variable-speed or Ward Leonard drive. The constant-speed drive operates one water pump, two large vacuum pumps for the suction rolls, and four small pumps for suction boxes, all of which are located in the machine room basement. Inasmuch as these seven pieces of equipment must operate simultaneously (for a shutdown of any one would mean that the entire paper machine must be shut down), group drive was selected as being the most economical in operation and first cost. The constant-speed drive is illustrated in Fig. 8. It consists of a 125-hp., 585-r.p.m., Crocker-Wheeler squirrel-cage induction motor belted to a lineshaft running in ball-bearing pillow blocks mounted on concrete pedestals resting on the basement floor. Inspection of Fig. 8 will show how the use of belts lends itself to driving of pumps, etc., which must be driven at various speeds and be located at different distances from the lineshaft, due to limitations caused by piping and building columns.

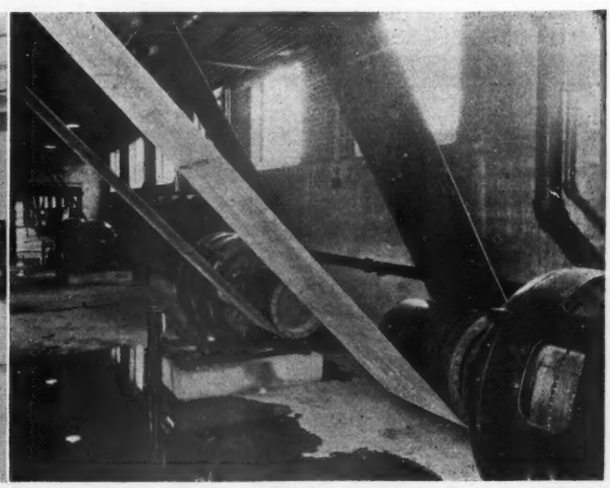
The variable-speed or Ward-Leonard drive consists of a motor-generator set (shown at the right in Fig. 11) supplying variable-voltage direct current to a shunt-wound motor belted to a long lineshaft which, in turn, is belted to the seven sections of the paper machine on the floor above. The shunt-wound motor and the long lineshaft which are located in the basement beneath the machine room, are shown in Fig. 2. This lineshaft also runs in ball-bearing pillow blocks supported in the same manner as those for the other lineshafts. The motor, which is shown at the left of the illustration just mentioned, is equipped with two sizes of pulleys on the armature shaft which may be belted to two different sizes of pulleys on the lineshaft, thereby obtaining two ranges of speed. These two changes combined with the change in speed by the manipulation of the generator and shunt motor fields, give a total range from 80 to 800 ft. per minute on the paper machine.

The lineshaft just mentioned is belted to countershafts on the floor above, which in turn are geared to the different sections of the paper machine. To enable any section of the paper machine to be cut out, Cutler-Hammer magnetic clutches are provided on each countershaft to disconnect the pulley from the gear.

The control for the machine room has been grouped together as shown in Fig. 11. The two panels at the extreme right are the Allen-Bradley control for the motor-generator set shown in the right foreground and for the variable-speed shunt motor. The third panel from the right is

Figs. 9 and 10—Belt drive is used for the beaters.
Fig.9, left, shows the four beaters that are individually driven by the wound-rotor motors shown in Fig. 10, right. The sheet metal cabinet at the extreme right of Fig. 9 contains a horsepower meter and the start and stop buttons for No. 4, beater. A similar cabinet is located adjacent to each beater. These buttons operate the controllers shown in Fig. 1.





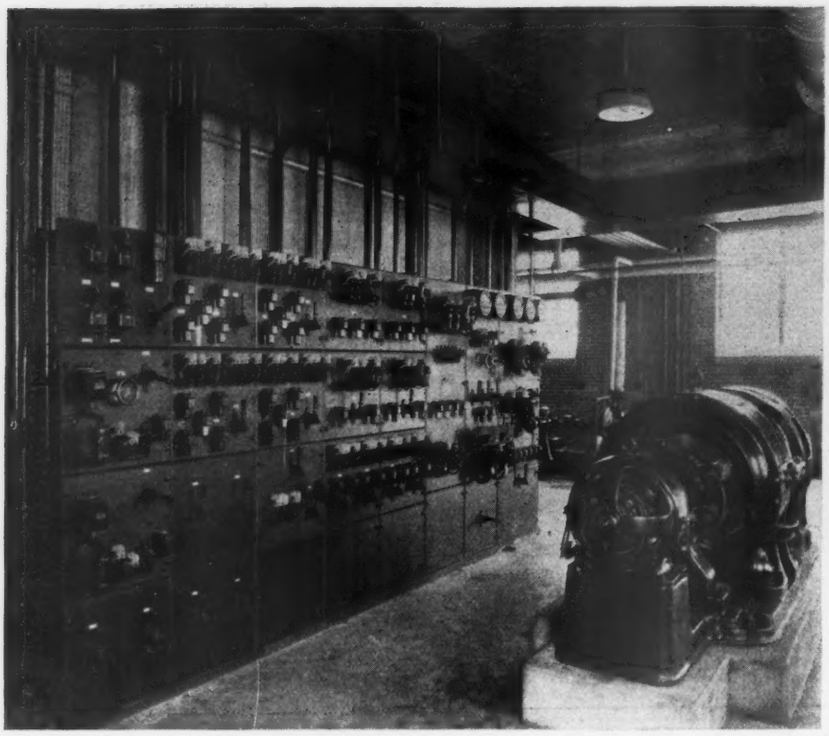


Fig. 11—Large junction boxes located over the control boards greatly simplify the conduit layout. Sections of one side of the boxes are hinged as shown so as to permit ready inspection of the wiring. The wires are carried on racks inside of the junction box, as may be seen. This control board contains all of the controllers for the machine room. The motor-generator set at the right furnishes the variable-voltage supply for the variable-speed, paper machine drive.

the control for the constant-speed drive motor. The remaining panels are for the various auxiliary drives in the machine room and are listed in Table III.

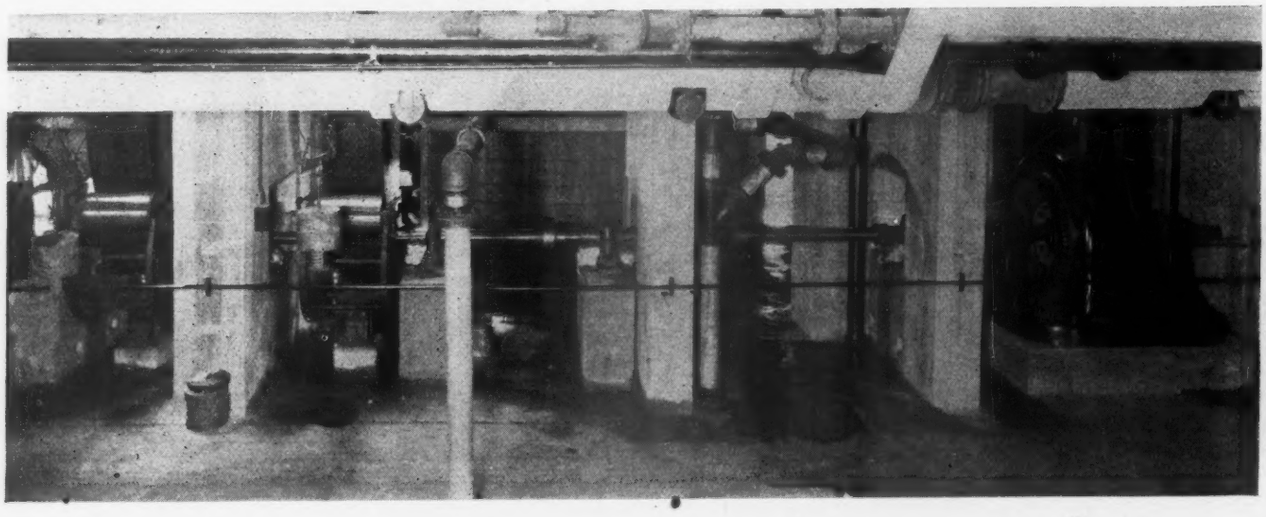
As has been said before, push-button control is used throughout. One of the push-button stations is shown in Fig. 3. Directly above the push buttons are two wattmeters calibrated in horsepower so as to give the operator an idea of the amount of power being drawn by the machines controlled by the push buttons. These meters are used in adjusting the amount of shredding that each Jordan does whether they are connected in series or parallel. It also provides a means of setting the machine to duplicate a product previously produced. In this connection, it may be said that similar meters are used on all of the larger drives throughout this plant, with the idea that these would help the operators to set their machines to duplicate conditions that have formerly been obtained. Careful readings are taken on these meters for every grade of paper that is put through.

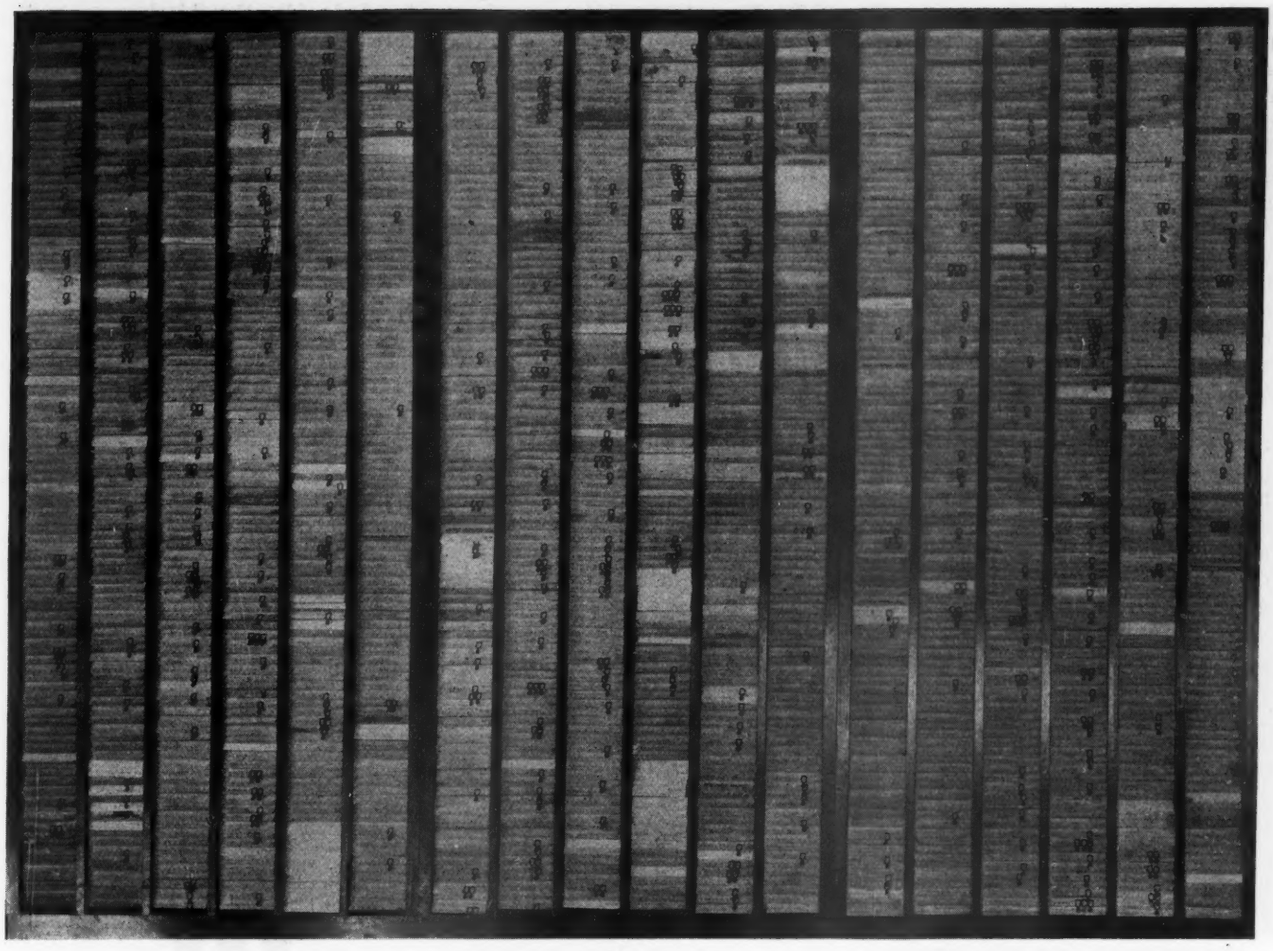
This mill has a connected load of 583 hp. in squirrel-cage, induction motors, 590 hp. in wound-rotor motors and 895 hp. in synchronous motors. For normal operation the four wound-rotor motors on the beaters would be shut down, thereby giving a total connected load of 833 hp. in induction motors as compared with 895 hp. in synchronous motors. As might be expected from such a combination the power factor is very high, in general averaging about 95 per cent.

With the exception of the motors on the beater drives, practically all of the squirrel-cage and wound-rotor motors were furnished by the Allis-Chalmers Mfg. Co. Thirty-five of these motors are equipped with Timken roller bearings. A saving in maintenance and repair expense, less oil trouble and less greasing is expected through their use. So far the bearings have operated for eight months with absolutely no trouble whatsoever.

These bearings, together with the ball bearings in the lineshaft pillow boxes, are equipped with Alemite nipples for the Alemite system of pressure lubrication. No grease has been put into the motor bearings since the time of installation, although the motor bearings have been inspected from time to time. Every indication points to the fact that greasing will be required only at yearly intervals.

Fig. 12 — A synchronous motor drives a group of four beaters through a lineshaft. The synchronous motor is coupled directly to the lineshaft. A Lenix Drive, as shown at the left, is used on each lineshaft pulley to permit the belts driving the beaters to hang slack during starting or for independently stopping any beater. Use of the Lenix Drives also makes it possible to place the lineshaft directly under, and at a short distance from, the beater pulleys.





The cards in this rack give a visual record of the operation of more than 3,000 motors in a large steel plant. Only three of the total of five sections used, are shown. Each section contains 600 cards. The cards are filed vertically in rows according to the location of the motors they represent. The name of the foreman in charge of a division is placed at the beginning of the corresponding section in the rack.

Ways in which a

Visual Record System for Motor Failures

enables the man responsible for the operation of a large number of motors to check their performance and thereby reduce the number of production delays occurring on them

By COMER D. HAZEN

Asst. Chief Electrician, Youngstown Sheet & Tube Co., Youngstown, O.

HAVE YOU EVER wanted to know quickly just how many motor failures you had in a given time and where these failures were? Have you wished for something like a map, upon which you could look and say, "I have had four failures here, two over there and only one at the other place?" Mr. Hazen, herein describes a system which in reality is a map of the motor casualties on the battlefield of operation. His system is simple yet it gives him an accurate picture of what is going on among 3,000 motors in his plant.

MOST motor record systems are made up in the form of cards which are filed in cabinets or drawers. On these cards more or less complete data is given regarding the motor and the machine driven by it. When ordering spare parts or determining rewinding data for the motors, such a record is very convenient for it provides a complete record of the details regarding a given motor. Some systems also provide a space for recording the failures on the motor and the cost of the required repairs. This is of value in determining the cost of operating a motor on a certain machine or in a certain location. However, the information is hidden away and, in case of a large number of motors, it is necessary to go through many cards in order to determine the frequency of motor failures.

In a steel plant, the most important thing is to keep the motor running. The man in charge of the maintenance and operation of the power drives is judged more or less by the number of delays that occur on the equipment he is responsible for. Hence, the important fact to be recorded is how many times each motor has failed in service within a given length of time and what were the causes of these failures.

With this idea in mind a visual record system for motors was devised that would enable the man responsible for their operation to check their performance at a glance. It consists essentially of a rack accommodating 3,000 cards, which hangs on the wall of the office of the *Electrical Department*. This rack is very similar to the racks used in timekeeping departments for holding the time cards. It occupies a space 5 ft. high and 10 ft. wide. The rack is built in sections, each section holding 600 cards, as shown in the illustration on page 517. Each section is made of a wooden frame composed of seven vertical strips held at the top and bottom by horizontal strips. The vertical strips are slotted at an angle as shown in the working drawing on this page, so as to hold galvanized iron separators, which make the pockets in which the cards are kept. Careful inspection of the working drawing just referred to and the illustration of three sections of the rack shown on page 517 will give a clear idea of the construction. Each pocket is inclined slightly off the vertical so that the cards are held upright with only a half-inch of the top of each card visible. By inclining the cards, as described, the pockets fit behind each other in such a manner that from the front all that is visible is vertical rows of cards, as shown in the illustration on page 517.

The record cards used in this system are 3¼ in. wide by 7½ in. long and are made up as shown on this page. In the upper left-hand corner is a space for the number designating the drive on which the motor is used. This designation consists of two letters indicating the plant division in which the drive is located, and the number of the motor. For instance, PL 64 indicates motor No. 64 in the plate mill; SM 19 indicates No. 19 drive in the sheet mill, and so on. The latter drive happens to be on a crane; so there are three cards with this same number—one for the bridge motor, another for the trolley motor, and a third card for the hoist motor. In a case of this kind all three cards go in the same pocket of the rack. Hence, each pocket in the rack represents one complete drive application.

Beneath the numbers just mentioned, spaces are provided for recording the name of the department in which the motor is located, manufacturer's name, character of field winding, class, form, horsepower, voltage, amperes, frame number, and speed of the motor. There is also a place for recording the brushholder data, and the number, size and make of brushes. Below these data is a place for writing in the name of the particular application the motor drives. The remainder of the card is used for recording the date of the motor failures and the reason for each failure.

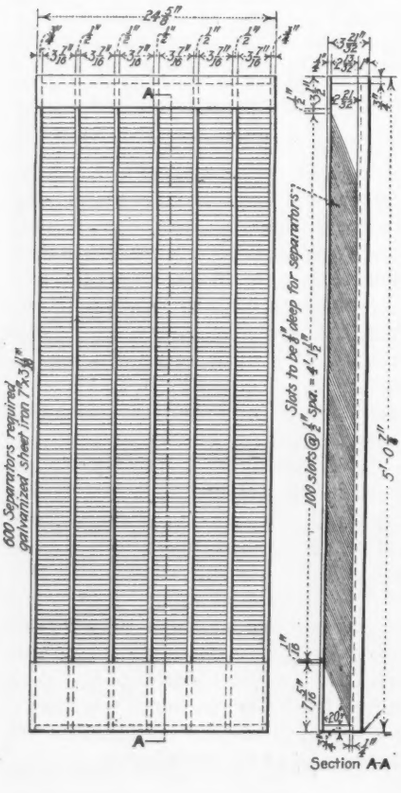
After making a motor or armature replacement, the foreman in charge of that division in which the delay occurred, makes a note of the failure in his daily report, telling the reason for the failure and the length of the delay. The clerk in the *Electrical Department* receives this report the following morning and enters all failures immediately on the cards just described. When the first failure occurs he places a black tab on the cards, as shown in the illustrations. On the occasion of the second failure, a green tab is placed beside the black one and thereafter for every failure during the remainder of the year an additional red tab is attached to the card. At the end of the year, the slate is wiped clean, all the tabs are removed and a new start is made.

As the cards sit in the racks only the motor location number and the colored tabs are visible; hence the attention of the electrical superintendent is quickly drawn to any cards that show troubles or delays. The cards are arranged in the racks according to the geographical divisions of the plant and at the start of the row of cards for each district is placed the name of the foreman having charge of the motors in that division. In this manner the electrical superintendent has a visual

(*Please turn to page 554*)

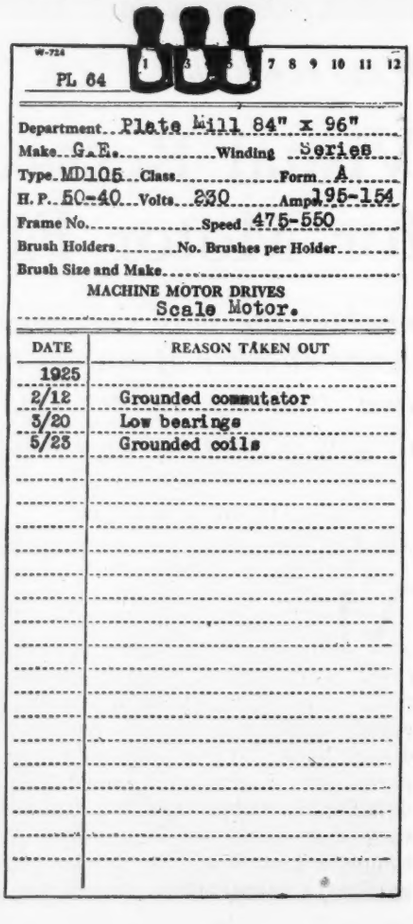
Five sections made up like this compose the rack for holding the record cards.

Each section of the rack is made of seven vertical wood strips held at top and bottom by horizontal wood members, as shown in the left-hand view. The vertical strips are slotted ⅛ in. deep at an angle as shown in the right-hand view, which is a side elevation of the rack. Galvanized iron separators are held between opposite slots on the adjacent vertical members, as shown in the left-hand view. The back of the rack is tightly closed in by boards as shown at the right.


600 Separators required, galvanized sheet iron 7"x3¼"
Slots to be ⅛" deep for separators
100 slots @ 3/16" Spac. = 1'-6¾"
5'-0"
Section A-A

Colored tabs are used to indicate the number of motor failures.

On this card are recorded the data regarding the motor, the location of the drive and the name of the machine it drives. In the lower half of the card, the dates and reasons for motor failures are tabulated. When the first failure for the year occurs, a black tab is placed at the top of the card, as shown. On the second failure, a green tab is placed beside the black one, and for every failure thereafter during the remainder of the year, an additional red tab is placed on the card.


W-724

PL 64 1 2 3 4 5 6 7 8 9 10 11 12

Department Plate Mill 84" x 96"

Make G.E. Winding Series

Type MD105 Class Form A

H. P. 50-40 Volts 230 Amps 195-154

Frame No. Speed 475-550

Brush Holders No. Brushes per Holder

Brush Size and Make

MACHINE MOTOR DRIVES

Scale Motor.

DATE	REASON TAKEN OUT
1925	
2/12	Grounded commutator
5/20	Low bearings
5/23	Grounded coils

Fig. 1—Buildings with wooden roof truss construction present some of the most difficult problems met in erecting lineshafts. This special truss extending between the roof trusses, and on which the shaft is mounted, has been found to be very substantial.

Practical pointers on the

Groundwork Necessary Before Erecting a Lineshaft

so that it will be rigidly supported and will maintain proper alignment in concrete, mill construction and other types of buildings

By GEORGE TRIMM

Millwright Superintendent, Chicago Pulley & Shafting Co., Chicago, Ill.

ERECTING a lineshaft is a job which requires at least experienced supervision. Also, with experienced millwrights the construction can go up quicker, better, and cheaper. In such work as this, much depends upon the knowledge and previous experience of the men, as it would be difficult and almost impracticable to attempt to work out by mathematical formulas the strength of the various constructions and of the bracing and lagging necessary. Also, so much depends upon the freedom from vibration and sagging of the building that good judgment in placing the bracing is often more necessary than actual strength of materials.

Some of the important points always to keep in mind in the preliminary construction or groundwork before the erection of a lineshaft depends so much upon the type of the building that they are more easily explained by connecting them to specific examples, some of which are given later in this article.

There is hardly any type of building construction which is not encountered when erecting lineshafts, even though it was never originally intended to bear the extra weight. This is particularly true in Chicago, and probably other large cities, where buildings which were originally erected for garages, single-story buildings built for floor storage, stores, lofts, and even offices are later used for laundries and so-called light manufacturing, which sometimes makes heavy demands upon the construction. These types of building construction cause probably the most difficult problems in connection with the erection of a lineshaft and will be discussed more fully later.

In some ways substantial, mill-construction buildings are the easiest in which to erect a lineshaft. The problem becomes more difficult as the quality of the construction decreases. Reinforced concrete construction has a good, substantial ceiling for erecting a lineshaft. Saw-toothed roof buildings offer a

problem of construction similar to that encountered with other trussed roofs. Each of these types will be discussed more fully later in the article.

A good example of a lineshaft installation in a mill-type building is shown in the illustration in Fig. 7. This shows part of a 100-ft., 2 15/16-in. lineshaft at the Chicago plant of the Wolff Mfg. Co. This shaft is to be driven by a 30-hp. Allis-Chalmers motor and will operate at 209 r.p.m. The five 20-ft. lengths of 2 15/16-in. turned and ground shaft are connected by Griptite keyless, compression couplings. A 44-in. by 10-in. Oneida split-steel pulley is also clamped on the shaft with a keyless, cast-iron bushing bored to clamp fit. Cast-iron, four-point adjustable, drop hangers with a 22-in.—24-in. frame are spaced 8 ft. apart, which is standard spacing for practically all cases except on shafts operating under severe service, or where a shaft is small for its load, or where a number of additional pulleys and loads are added and it becomes necessary to insert additional hangers about midway between the hangers already installed. An example of this will be given later.

In this installation the driving pulley is placed at the center of the shaft, which will be approximately the center of the driving load. The hangers on each side of the driving pulley are placed 4 ft. apart, which will eliminate any possibility of whip or weave due to the pull of the belt. This shaft is to be used to drive a double row of buffing and polishing wheels and, as laid out, will not drive enough machines to equal its capacity. It is a good plan to provide greater capacity in such installations than is necessary for the machines planned for the initial installation as practically always more machines are added later. An extra ⅛ in. or ¼ in. in the diameter of the shafting costs comparatively little more and practically nothing more for erection.

In the case of this installation at the Wolff plant, Fig. 7, the building is of substantial mill construction and the ceiling practically level, so that the actual job of erecting the shaft was comparatively simple. The footings which support the hangers were made of 3-in. by 10-in. yellow pine plank. The ceiling beams are spaced about 36 in. center to center and the footings are fastened on with four ⅝-in. by 7-in. lagscrews. Holes 11/16 in. in diameter were bored in the cleats or footings and ½-in. holes in the joists for the lagscrews.

In erecting lineshafts in mill-constructed and most other multi-story buildings, a point which may cause difficulty is a ceiling construction which is too light, so that the ceiling gives with passing loads on the floor above, or when material or machines are placed on the floor above. In such a case as this a good practice is to install and line up the shaft under the conditions as found at that time. In about a month or so, it is well to go over the shaft again and line it up to see if there has been any deflection in the ceiling which has affected the shaft. This will take care of the loading caused by machines on the floor above.

In case the ceiling gives with a passing load, little can be done to remedy it. However, where the floor above is used for storage, it is best to realign the shaft every time the floor is filled up or emptied as in some cases deflections of over an inch have been found in the center of the ceiling span. Lineshafts which are an inch out of alignment will create a very heavy friction load in the bearings.

Another serious problem in any installation arises where the joists are uneven. In such a case it is necessary generally to put some blocking under the footing at one end or the other. The best way to get this footing square is to use a plumb-bob or a vertical level and a T-square. Sometimes it is possible to level the footing on the top side, if it is finished lumber; this would have been possible with the shaft installed in the Wolff plant if it had been necessary.

In case the roof or ceiling slopes toward one end of the building, a type of construction which is frequently found on the top floor of loft buildings, it is practically always necessary to work from a line

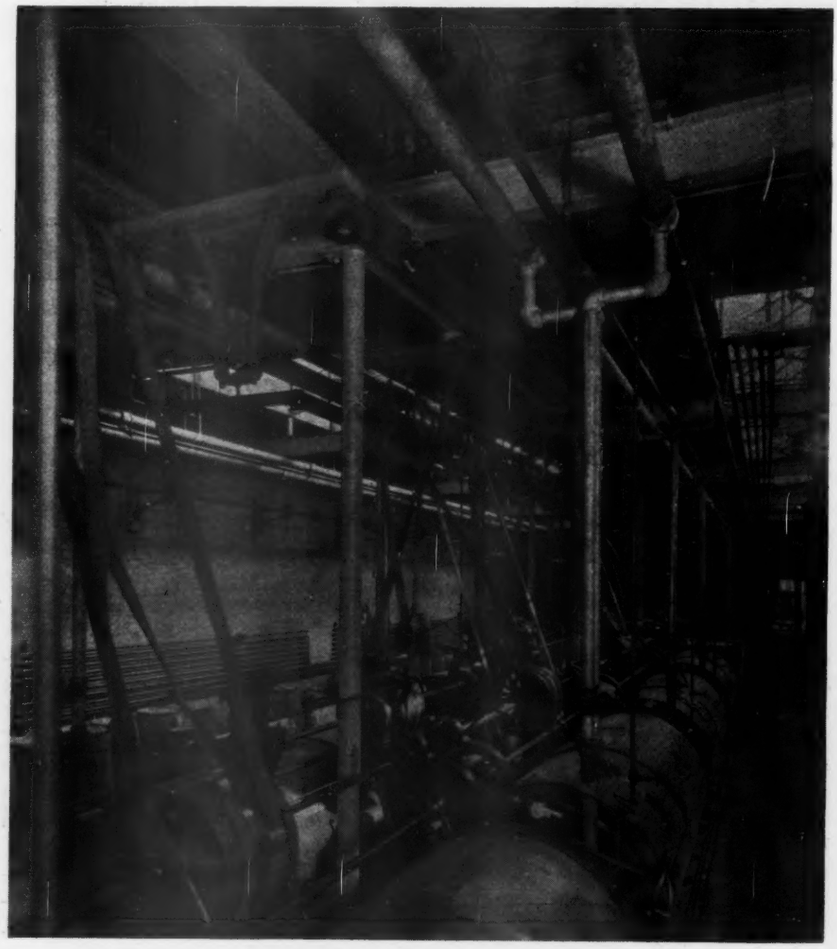


Fig. 2—In the installation at the Alert Wet Wash Laundry, Chicago, Ill., it was possible to fasten each footing to an I-beam with beam clamps.

In addition, the footings were fastened to the ceiling by special stringers. The method of extending a shaft over the light-well in the center of the building is shown in Fig. 3.

Fig. 5—This is a view of a different part of the paint mill shown in Fig. 8. This type of lineshaft installation is used throughout the plant.

Here the footings for the lineshaft are fastened to the concrete ceiling by expansion shells and the hangers are bolted to these footings. Concrete buildings give probably the most substantial supports to a lineshaft.

stretched from one end of the buiding to the other, or the length of the shaft. The line is leveled by the use of a line level, which is a small, light and very sensitive level which may be hung on the center of a taut line without deflecting it perceptibly. By working from this line it is possible to measure to the ceiling at each of the varying heights and build up the necessary blocking so as to provide a substantial footing for the lineshaft.

To make this footing more substantial it is generally advisable and practically always necessary to run stringers the full length of the shaft and fasten the hangers to the stringers or to footing blocks bolted to the stringers. An installation of this kind where the roof has a considerable slant is shown in Figs. 2 and 3; these illustrations were taken in a laundry. In cases of this sort 2-in. by 8-in. or 2-in. by 10-in. planks are commonly used for the blocking, with 4-in. by 4-in. or 4-in. by 6-in. timbers as stringers.

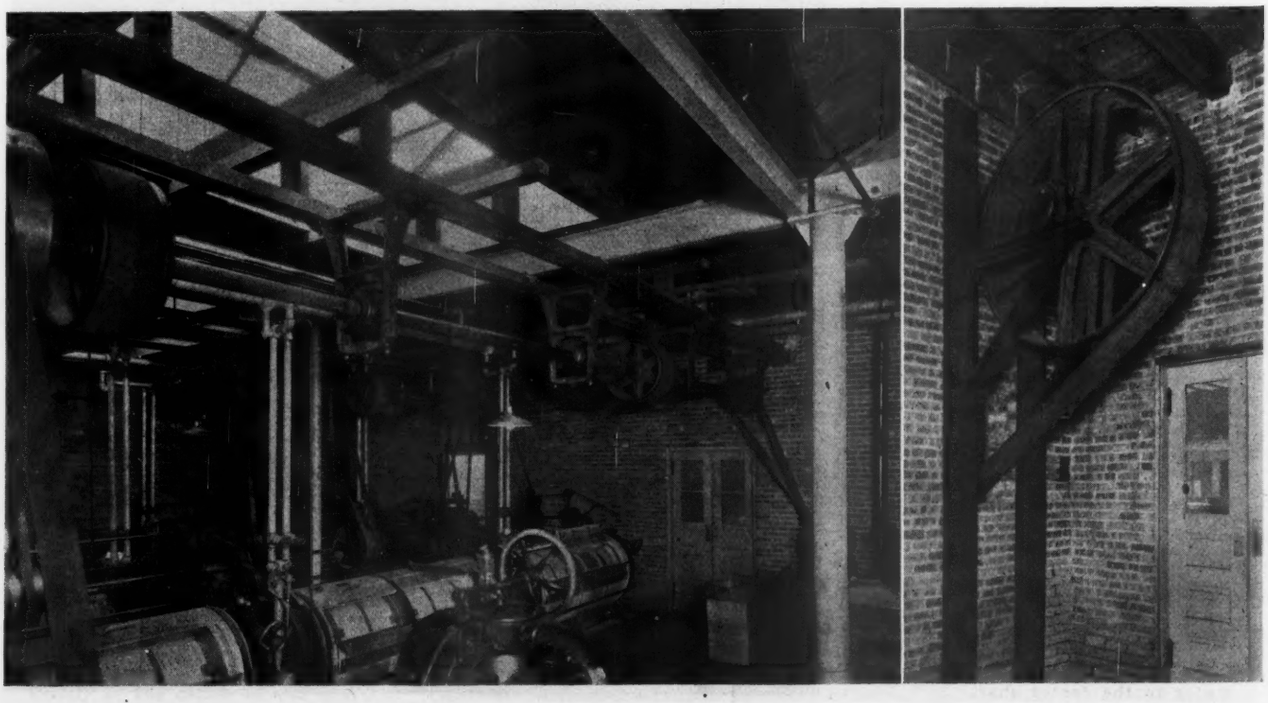
If, in the installation at the Wolff plant, it had been necessary to extend the lineshaft at a right angle to that shown in the illustration, so that it would cross the joists instead of running in the same direction, it would have been necessary to lay stringers across the joists and lagged to them. The footings would then be bolted to the stringers. It would be advisable to lagscrew stringers to the joists on each side of the footings.

Sometimes it is necessary to run shafts diagonally across a ceiling, as is shown in Fig. 6. The construction is shown clearly in this illustration. A series of parallel shafts belted to each other is more expensive to erect than a single shaft but frequently the layout of the machines makes it necessary. This is often the case in long, narrow buildings.

In case of a building with laminated floor construction, that is, where the floor and ceiling are made up of 8-in. or 10-in. planks on edge, nailed together, it is extremely difficult to erect a lineshaft on the ceiling so that it is not subject to a "weave" transmitted by trucking or any motion or vibration of machines on the floor above. In such cases

Figs. 3 and 4—These illustrations show the mounting of the main drive shaft, at the other end of the room shown in Fig. 2.

This ball-bearing main drive shaft extends through the wall at the door to a main driving pulley which is belted to an engine; the method of mounting the shaft at the driving pulley is shown at the right. Fig. 3 at the left, shows a special staging which is necessary to carry the lineshaft across under the lightwell. Where possible the stringers were clamped to the I-beams, although this alone was not sufficient. Fig. 4, at the right, shows how wall brackets and ball-bearing pillow blocks may be used to mount a shaft along a partition wall, and the bracing which was necessary to prevent the wall giving under the load of the shaft and pulley.



it is best to lay stringers and lag-screw them to this ceiling. Footings are then attached to the stringers by lagscrews.

We believe that it is advisable to use footing planks for attaching hangers as they not only give a substantial base from which to work, but also permit the use of a bolt instead of a lagscrew for attaching the feet of a hanger. This permits making adjustment by shifting the feet at any time without loosening the thread made by the lagscrew.

We use a tight line as a base for practically all our work. This is leveled by the use of a line level and if over about 40 or 50 ft. long is generally supported in the center so that it will eliminate errors which might creep in due to sag. A large proportion of the objections to the use of a line is due to the fact that the men using it are not experienced enough and do not exercise sufficient care to see that it is level.

Perhaps one of the most difficult types of construction for supporting a lineshaft is in buildings with a frame truss roof support. A typical installation in a building of this type was made at the Ideal Wet Wash Laundry, Chicago, Ill., as shown in Fig. 1 at the beginning of this article. Another type of construction for supporting lineshafts under similar conditions is to lay 6-in. by 6-in. stringers from one truss to the next and to support the lineshafts on footings attached to these stringers. This type of construction, however, is subject to the natural sag due to the weight of the shaft, with a consequent misalignment of the shaft.

A better form of truss which is easily constructed and installed is shown in this illustration of the Ideal Wet Wash installation, Fig. 1. This truss which may be seen extending between the first two roof trusses in the foreground of the illustration is made of 2-in. by 6-in. and 2-in. by 8-in. planks with cross braces, and bolted together as shown. Diagonal braces extend from the side of this brace to the roof truss to prevent side-sway. The footings for the hangers are bolted to this special truss.

In this construction, a special truss is put up between each of the roof trusses. Each of these is bolted together at the ends and with the side bracing does not show any vibration even under the severe service in a laundry. Laundry service is severe in that a washing machine makes a certain number of revolutions in one direction, then reverses, makes the same number of turns in the opposite direction, and repeats this continuously. This is a 1 15/16-in. turned and ground shaft 40 ft. long and equipped with SKF ball-bearing hangers.

Still another type of construction was required in the installation of the lineshaft which is attached to the back wall, as also shown in Fig. 1. This is also 1 15/16-in. lineshaft, 60 ft. long, and is supported by SKF bracket hangers. The footings here consist of 6-in. by 6-in. pieces of timber which are bolted to the wall with the bolt head held by a steel plate on the outside of the wall. One of the most important points to consider in attaching hangers to a wall is to provide a substantial footing so that the hanger will have a base of sufficient size so that it is mounted firmly and on a large area of brick wall. The mere size of the timbers is not the important point, however; it is more important to see that they are placed where they can be used to best advantage.

In the lineshaft installation made at the Alert Wet Wash Laundry, Chicago, Ill., Fig. 2, the roof is supported on steel I-beams, which in turn are supported on cast-iron posts. This offers a still different problem. Here the footings for the hangers are supported partially by an I-beam supporting the roof joists and extending parallel to the shaft. In addition, 3-in. by 8-in. stringers are extended alongside the I-beam and bolted up to the ceiling, with special bracing. This is shown more clearly in Fig. 3, which was taken in the same laundry at the other end of the room, at the main drive shaft. How this footing is clamped and attached to the I-beam is shown in the second hanger in this illustration. Here a block under the footing is attached to the I-beam by beam clamps which are bolted to the footing and clamp over the flanges.

In a case like this, wooden stringers may be used because they can be supported in several places,

Fig. 6—Method used in installing a lineshaft diagonally across the building.

When it is desired to stagger the machines without using a twisted belt it is sometimes necessary to install a number of parallel shafts, as was done here, with each shaft driving the next. This is a mill-constructed building and the cleats or footings for the hangers are fastened to the joists by lagscrews. It was necessary to use two cleats for each hanger. Instead of countershafts each machine is driven directly from the lineshaft through a clutch pulley. Cutoff couplings permit sections of the shaft to be cut out if necessary. The placing of the lineshaft is generally secondary to the desired placing of the machines. Sometimes in long, narrow buildings, it is necessary to install the machines in rows crosswise in the building. In such cases, it is generally necessary to run a number of rows of parallel lineshafts connected together by belts, using only one motor to drive the group. Wherever possible, in such cases, it is advisable to connect the motor to the center shaft.

Fig. 8—This lineshaft was installed in a reinforced concrete building.

Here the footings for the lineshaft, clutch shifters, and also footings to support a monorail I-beam are attached to the concrete ceiling by the use of expansion shells. This is a 2 7/16-in. shaft mounted in SKF ball-bearing hangers. Countershafts are eliminated entirely in this installation in a Chicago paint mill by the use of ball-bearing clutch pulleys.

whereas with the wooden truss roof the only possible method of supporting the truss or stringers is at the ends. Also, the method of clamping the hanger footing to the I-beam helps to give added rigidity. This is a substantial method of supporting lineshaft and does not permit any vibration in operation, even under the severe service of the reversing motion of the washing machine.

A lineshaft is supported on the wall in Fig. 2 in much the same manner as was used at the Ideal Wet Wash, shown in Fig. 1. Here, however, the footing is not so heavy because it was not necessary to carry the lineshaft quite so far away from the wall. This footing is also bolted through the wall, with the bolt heads held by steel plates.

Fig. 3 shows the main drive in this same laundry. This illustration shows clearly the method of mounting the stringers and also the beam clamps which are used to fasten this stringer to the cross I-beam. Here it was necessary to insert special staging to cross over a sky-light. The method of construction and blocking necessary may easily be understood from the illustration.

The lineshaft in the background and the one attached to the wall are the same as shown in Fig. 2. This main lineshaft is 2 7/16-in. in diameter and extends through the wall to a 44-in. by 10-in., double-arm, Oneida split-steel pulley which is driven by an engine. The mounting of the driving end of this main shaft, Fig. 4, shows the application of a wall bracket and an SKF ball-bearing, pillow block for supporting the driving end of the shafting. Here the wall brackets are mounted on 3-in. by 10-in. planks set upright against the wall. Another pair of planks is also placed on the other side of the wall. These are bolted together with steel plates used under bolt heads and nuts, which gives sufficient bearing surface so that the bolts will not loosen during operation, as might be the case if the bolt heads were placed directly against the wood. The planking is also bolted through the wall both above and below the wall brackets. This ties the whole wall up solid and gives practically the whole area of the side of the planks as a bearing surface.

When fastening lineshafts to the ceilings of reinforced-concrete-constructed buildings, a very common method is to use special steel inserts which are cast in the concrete. However, in many cases industrial plant engineers do not know, when the building is built, exactly where the lineshaft is to extend, or find it necessary to make changes after the building is up. This necessitates then that the hangers be fastened

(*Please turn to page 554*)

Fig. 7 — Substantially-built, mill construction buildings are generally the most satisfactory for erecting lineshafts.

This is one of three shafts recently erected at the plant of the Wolff Mfg. Co., Chicago, Ill. The drop hangers are spaced on 8-ft. centers, except at the driving pulley, where the hangers are on 4-ft. centers. The footings or cleats for supporting the hangers are fastened to the joists with two lagscrews at each end. This is a 2 15/16-in. shaft, 100 ft. long. The motor is so placed that the driving pulley is approximately in the center of the shaft.

Fig. 1—This is the rewinding section of the repair shop.
The man at *A* at the left is testing an armature with its top leads raised with a megohmer for insulation resistance. A final millivoltmeter bar-to-bar test, *B*, is made on all finished armatures. Soldering, *C*, is done with a double-flame torch. The operator, *D*, is taping coils and has at his right a pile of finished coils. The testing board, *E*, consists of parallel and series lamp banks. Some of the lamps are removed here to give a better view of the board.

Details of methods and equipment used in

Rewinding and Repairing Armatures and Motors

which operate under severe service conditions, together with shop tests and records that show the quality of the work

By CHESTER A. WILLIAMS
Electrical Repair Shop, Providence Gas Company, Providence, R. I.

PLANT repair shop practices, methods and equipment are governed largely by the amount of work to be done and the conditions under which the equipment is operating. The large shop can adopt ideal equipment and the best and most economical methods. The small shop is often forced to use what it can design and construct itself. Additions to the equipment, however, are made gradually as the shop feels it can afford them and can convince the management of their economy, desirability and necessity.

The number of repairs necessary and the kind or extent depend to a large extent upon the conditions under which the motors and other equipment operates. The manufacture of gas is a process which continues, with some fluctuations, 24 hr. a day and 365 days a year. A motor, which is operating in evenly-heated and well-ventilated buildings under conditions free from acid or corrosive fumes and conducting dusts, requires entirely different repair practices from one operating under adverse conditions. The manufacture of gas and by-products is a good example of the adverse conditions in which the three worst enemies of electrical equipment are coke dust, ammonia and extremes of temperature. Of the three, coke dust, which contains 87 per cent or more of carbon, is the worst enemy; electrically, by short-circuiting the windings and commutators, and mechanically, by causing serious bearing trouble.

At the plant of the Providence Gas Co. approximately 150 motors of nearly 2,000 hp. total rating are required to operate the equipment. The direct-current motors range from 1 to 75 hp. and the alternating-current motors from 1 to 300 hp. The majority of the motors range from 10 to 20 hp. Direct current is generated at 250 volts. The alternating-current equipment is operated at 440 volts with purchased power.

A considerable number of these motors operate in an atmosphere of coke and coal dust. A few are directly subjected to ammonia fumes, which attack the copper and cause high-resistance contacts and poor commutation.

The crew required for inspection and repair of this equipment is composed of the foreman, one night and one day maintenance men and two helpers, one oiler, one armature winder and helper and a construction man and helper. The night and day maintenance men inspect the equipment and do any necessary troubleshooting. The two helpers work on the day shift, either with the day man or on any necessary repairing, overhauling or other miscellaneous work which comes up. The oiler blows out the equipment

Do Following work on this piece:

Date 11/25 Chg. Acct.# 144- M.O#

Name of piece Armatures

Symbol No. or (S.K. 70 (W)
Where Located (Coke crusher

Winding - (new) - repair

Commutator - (repair) - (turn)

Shaft - (build up) - (turn) - (grind) - polish

Keyway - (recut) - refinish (fit key)

Nuts - new - fit

Pinion or pulley - new - (fit)

(Fit bearings)

Checked by .....

Fig. 2—This work tag goes with all armatures sent to the machine shop.

Armature & Motor Rep'r Data

Date Rep'd 1/1/25 Installed .....

Symbol No. or (R.C. 8 Z
Where Located (

Mfrs. No Gen. Elec.

Trouble Grounded by coke & oil. Insulation under coil ends short.

Where Located Rear end

Reference Rewound - new coils - Mica ring installed under coil ends

Rep'd by H.

Test, BtoB. O.K. .... Ground .50 meg.

Tested by G.G.

Fig. 3—After all work is completed on an armature, it is tested and this record filed.

with compressed air and watches for any indications of possible bearing trouble, in addition to his oiling routine. The duties of the armature winder and the construction man, and their helpers, are obvious.

Equipment and Methods Used in Repairing Armatures

The equipment in the electrical repair shop includes a 36-in. by 8-ft. banding lathe, a 10-in. speed lathe, a 50-in. insulation cutter, a Segur bar loop winder, a wire loop winder, a taping machine, a 16-in. by 55-in. spreader, a two-wheel floor grinder, a 2-ton Peerless hoist and a 3½-lb. electric soldering iron. Figs. 1, 4 and 9 show different parts of this workshop and some of the work done. Commutator turning and all machine work are performed in the machine shop, a portion of which, containing several of the larger machine tools, is shown in Fig. 6.

Because most of our trouble with a motor is in the armature, we keep a large number of spare armatures instead of spare motors. Altogether there are a total of 61 spare armatures with at least one and in some cases two spares for every important piece of apparatus. This minimizes loss of production and allows more time for proper repairs.

Every spare armature is equipped with properly fitted bearings, a pinion or pulley and a key; special attention is given to the latter. Keys are machined to within 0.001 or 0.002 in., are fitted by hand filing until an even bearing is secured and are required to be driven in at least half way during the fitting before they are O.K.'d. This is a large factor in eliminating lost time and prevents unnecessary interruption of production when making a change.

Practically all bearings and pinions are made in the machine shop and the machinists do all the fitting to the journals. Spare armatures are stored on racks about 3 ft. from the floor, with a small exhaust steam coil under each rack. Steam is kept on during both summer and winter, so that the armatures are kept perfectly dry and slightly warm.

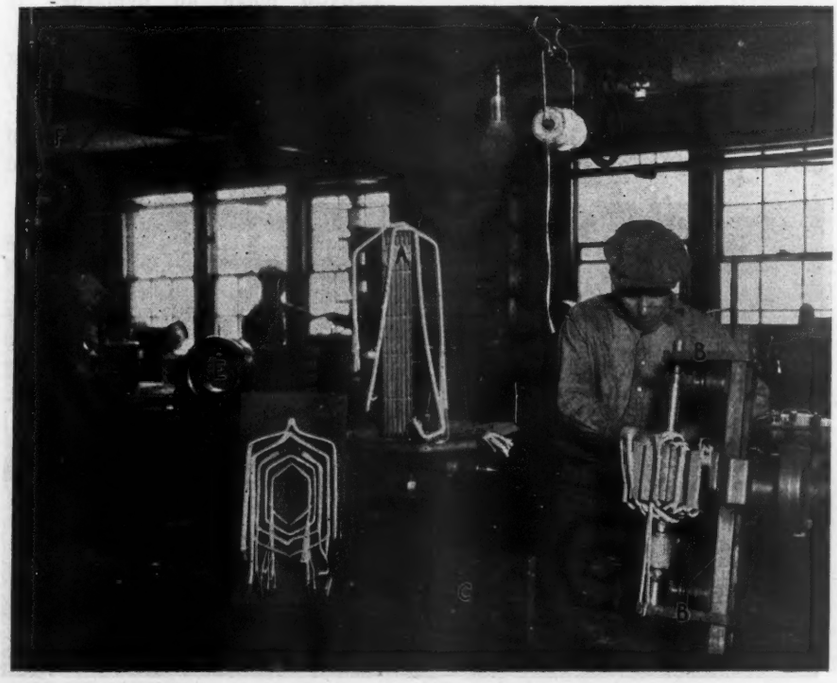


Fig. 4—Another section of the shop for the Electrical Department, and some of the types of work done.

On this special form for winding coils the wire is crossed over at the point marked *A*. A finished and unfinished coil which were made on this form are shown alongside. The attachment, *B*, to the hairpin loop winder is in use winding a 5-hp. armature. The adjustable form, *C*, is used for winding small wire coils. Several of the types of coils which are made in the shop are shown in *D*. The 1-hp. stator, *E*, has just been dipped and baked. Two sets of large field coils are shown on the bench at the right of *E* and the insulation rack and cutter are over by the wall and window. The air and gas connections, *F*, for the soldering torch are hung up when not in use.

Almost every type of armature repair is made, either in the *Electrical Department* or in the machine shop. Journals measuring 0.005 in. or more under standard are built up by arc welding and turned down in the machine shop. We do not build new commutators, but those which have carbonized mica are rebuilt and, occasionally, a bar or two is made to replace defective ones. if the commutator is otherwise good.

Approximately 100 armatures were repaired during 1924 and required the following quantity of materials: 243 lb. of magnet wire, 402 rolls of cotton tape, 22 rolls of silk tape, one 50-in. roll of fishpaper, 15 lb. of mica fishpaper, 31 18-in. by 36-in. sheets of segment and molding mica, 55 gal. insulating varnish, two rolls of 36 in. varnished cambric and 15 lb. of 1/16-in. sheet fiber. Also, 641 rolls of friction tape, 103 rolls of splicing compound and 275 lb. of

solder were used, either in the shop or around the plant.

The small amount of magnet wire used is due to the fact that we use old coils whenever possible for the larger sizes of armatures after they have been reinsulated. Also, several sets of coils were purchased about the first of the year.

The methods used in armature winding have been given special consideration, because at one time the life of certain newly-wound armatures used in the coke department was from two to three months. After considerable study of the problem we decided on the following method of procedure which is giving good results. Armatures with grounded or shorted coils are seldom repaired unless the repair be made without raising the coils. If the service is not severe and the winding seems good except for one or two coils, the damaged ones are cut in the loop, disconnected and jumpers put on. This is not only a quick and inexpensive repair but our records have shown that a smaller percentage are returned than when new coils are inserted.

If it is necessary to rewind the armature, the old coils are removed as carefully as possible and those showing a good test are reinsulated during spare time. The core is given a good cleaning and reinsulated. The commutator is required to stand a 50-megohm test between bars and to ground before being passed. This sometimes requires two days' time, but we consider that the new insulation makes it as good as a new one and our records of results show this to be good practice.

The usual string band is put on and the commutator is sealed at both ends by a small amount of Bakelite cement rubbed on with the finger in such manner as to give a thin coating over the string band and ends of bars. Too much Bakelite in any one place will bubble out during the baking and makes a poor job. Coils are baked to exclude moisture and

MOTOR CHECK CARD

Make of Motor.....Type.....Serial.....

Location.....Date.....

Are coils thoroughly insulated from ground....
Has polarity of coils been checked.....
Are coils a snug fit.....
Are field poles drawn tightly to frame.....
Are brush holders and studs tight.....
Did you get a 50 MEG. test between connected coils and ground.....
Are all coil connections and leads equipped with connectors.....
Are all leads through frame properly bushed with fiber.....
Does armature rotate freely.....
Has it about 1/8-in. end play.....
Are the bearing dowels in.....
Have the brushes been fitted to the commutator.....
Are they evenly spaced.....
Is the tension alike on all brushes.....
Have you checked the clearance between armature and poles.....
Are oil rings turning freely.....
Are the oil retainers and covers in place.....
Are there any screws or bolts missing.....

REMARKS.....

.....

.....

.....

.....

Signed.....

Fig. 5—The repairman must fill out this record, which is filed, on all overhauled motors before they are O.K.'d.

the winding is done in the usual manner after a three-cornered file has been run across each slot to eliminate any burrs.

Fishpaper is used for slot insulation. Bottom leads are placed as the winding progresses. When the coils are in and before the top leads are put down, another insulation resistance test, using a megger, or megohmer, is then given both between bars and to ground at one operation, by connecting one of the terminals to ground.

In passing from bar-to-bar for this test, if one of the coils or bars should be grounded it will show up through the third wire. On this test also the armature is required to show a resistance of 50 megohms.

The armature is finished in the usual manner. The soldering is done with a small gas-and-compressed air torch. Rosin and alcohol is the only flux used. Numerous tests have been made but no bad results have been noted to date from the use of the torch. A 5- to 10-hp. armature can be soldered in from 20 to 30 min. and we seldom have trouble from high-resistance connections. The completed winding is dipped in Sterling extra-insulating varnish, baked, and sent to the machine shop with the work tag, Fig. 2. When completed, a final bar-to-bar test is made with the millivoltmeter and the armature tested to ground. If it is O.K., the armature and motor repair data card, Fig. 3, is filled out and filed. This card has been an important factor in solving some of our trouble.

All armatures of the same make and type are stamped *Z*, *Y*, *X*, and so on, for purposes of identification. As an example of the value of this card, if two or more armatures, working under similar conditions, are returned for grounds at the rear end, extra precautions are taken to remedy this, as shown. The card also shows how long the armature has been in service, whether or not special precautions were taken, who repaired and tested it, and what the test showed. Our practice of making rigid tests has grown out of the use of this card and two brands of insulating varnish have been discontinued because of the poor results as shown by this record.

Usually when an armature is found with low bearings, it is replaced instead of merely changing the sleeves. As stated before, bearings are fitted to each spare armature. The next step is to raise all top leads and give a bar-to-bar and

Fig. 6—Mechanical repairs to electrical equipment are made in the Machine Shop.

Spare armatures, of which there is at least one for every important drive, are fitted with pinions or pulleys, keys and bearings in the machine shop before storing away. This makes a complete unit which can be installed quickly. Shafts which are worn down are built up by arc welding. The 20-hp. armature at *A* is fitted with its bearings, pinion and key, ready for storage. Only lead hammers are used for driving pinions. Several pinions are piled at the right of *A* and a number of bearings at *B*. At *C* is a 100-hp. armature fitted with spare endplates, bearings and pinion.

ground test with the megger, as described above, as we find that the millivoltmeter is unreliable on old work because it does not show up leaks due to carbonized mica and carbon dust. Old armatures which show a resistance of one megohm are passed if there is not much variation between bars and to ground.

Two-pole motor armatures are wound in the banding lathe, as shown in Fig. 4, by using a shop-made attachment to the coil winder. This procedure is much quicker, but requires careful insulation between coils at both front and rear. The usual winding time is 5 to 6 hr., including the time required to place the sleeving which is used on bottom leads only. We seldom try to repair coils in this type of armature, but occasionally cut them out and insert jumpers.

Our practice is to overhaul a complete unit at such time as a piece of equipment is shut down for any reason long enough for us to do so. We strip and clean the motor thoroughly, give it a coat of insulating paint and put in new coils. The old coils are later reinsulated, dipped in Sterling varnish, baked and put back in stock.

A large part of the success of our repair work is due, we believe, to the thoroughness of our tests and the records we keep on all repaired equipment. For example, after overhauling the motor, the repairman is required to check each item on the card, Fig. 5, before it is O.K.'d. When he knows that this information is put down in black and white and kept on file, he is sure that the test and record are right.

When the testing, after overhauling, is completed the motor is oiled and given a short running test for direction of rotation, speed, amperes at no load and brush setting. It may be interesting to note that in connection with the motor repair work, the following coils were replaced for failures during the year:

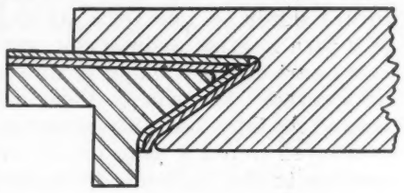


Fig. 7—This cross-section view indicates how the mica rings are formed for the cones of the commutator.

41 main field coils, 25 commutating coils, 27 resistor coils and 12 holding coils.

How Commutator Troubles and Repairs Are Handled

The repair work on commutators is confined mostly to carbonized mica segments and the outer cones which are damaged by shorts just under the edge of the bars. This trouble is being rapidly eliminated by the use of Bakelite cement. Most of the burned-out cones are traced to a combination of oil and coke dust which makes an excellent conductor. Mica segments are made by inserting a piece of segment mica between the two bars and holding them in a smooth, swivel-jaw vise. A fine-tooth hacksaw blade is used for cutting off the excess mica.

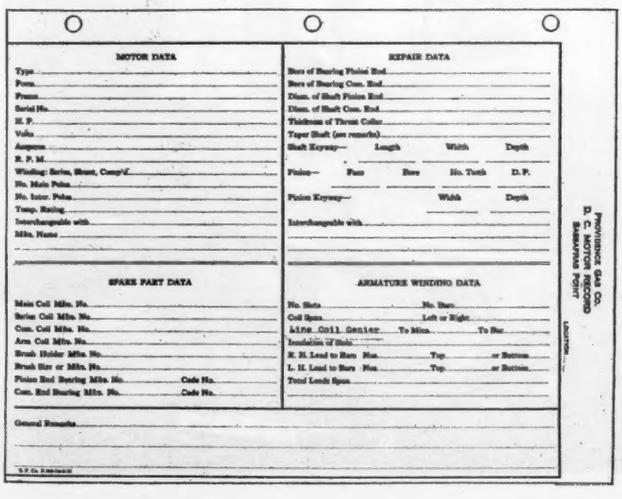
Cones are made from molding mica in the following manner: After laying out the pattern two pieces each for the inside and the outside rings are cut. Each piece is drawn through a flame to make it pliable before forming. Next, a piece for an outside mica ring is placed, while hot, around the iron cone and held until cool enough to retain its shape. It is then marked and cut 3/8-in. too long and the lap is halved in. The second mica is formed in the same way over the first and the inside rings are formed in similar fashion. The cross-section of one side is shown somewhat exaggerated in Fig. 7, which indicates how the rings are assembled after treating with varnish except for the parts coming in contact with the commutator. This and the iron cone are well heated and gradually drawn up tight. We have had splendid satisfaction from this method and it requires only about 45 min. to make the cones. Before discarding the pattern, a template is made of tin and the type of armature is stamped upon it. This saves considerable time on future work.

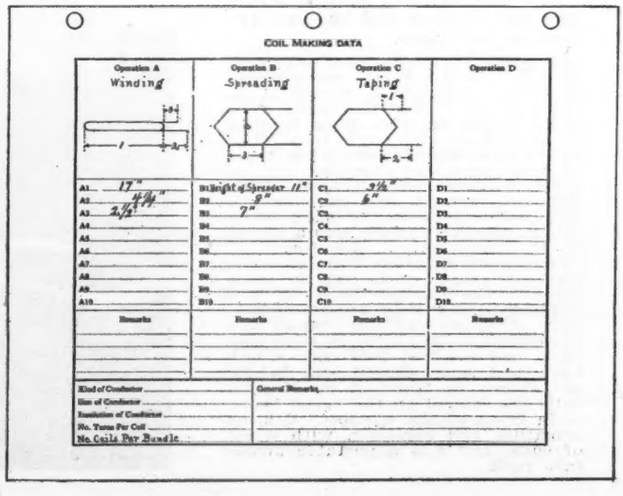
Commutators are undercut 1/64 in. if the motor is located in a clean place. Experience has indicated that it is bad practice to undercut the commutators on motors driving conveyors or crushers, and on boiler room motors. Acme commutator stones are used on these commutators as soon as any trouble occurs.

Armature Coil Making, Dipping and Baking Practice

When an armature is stripped for the first time, the winding data are recorded on the form, Figs. 8*A* and 8*B*, which is filed in a loose leaf binder. This reduces the set-up cost very materially, as it takes but a moment to set the winder and spreader to the scale as recorded on the sheet. Other time-saving features can be seen by a study of the

Figs. 8 A and 8 B—When an armature is stripped for the first time, the winding data are recorded on this loose-leaf sheet.





data which are recorded on this card.

Coils made on the hairpin loop winder are made and spread in the usual manner. We do not attempt to tape in cells as we have little trouble with coils breaking down in the slots. Fishpaper of sufficient thickness is used in the slots so that coils may fit snugly; the insulating varnish seals and makes them trouble-proof. Two sets of coils are always made at one time as this reduces the cost per coil of setting up the equipment.

Certain types of wire wound coils can be made much quicker in special forms. One such form, with a coil made on it, is shown at *A*, Fig. 4, which shows clearly how the form is made. The advantage in the use of the form lies in the reduction of the number of operations. This particular form is used to make 4-parallel, three coils per bundle, open coils from No. 13 wire and having rectangular ends when spread. The slots are the right width for three wires and are four wires deep; the coils are wound with three wires in hand. When one slot is filled (four deep), the winding is crossed over to the second slot (at *A*, Fig. 4) with only a momentary stop and the operation is continued until the six slots are full. After tying, the coils are sawed through with a fine-tooth hacksaw and then removed, dipped and baked before further operations are performed on them.

Our method of dipping and baking is somewhat unusual and would hardly be suitable for a large repair shop. The armature is put in the banding lathe and by the use of a space heater containing six Cutler-Hammer, 2-amp. units, all moisture is driven out. When dry, the heater is replaced by a pan blocked up as high as the shaft will permit and of a length sufficient to include the commutator, which is covered with a layer of paper and friction tape. The pan is filled as full as possible with varnish, and the armature turned slowly by hand, or a fraction of a turn is given at intervals, until every part of the winding is sure to be covered. The pan is then lowered to the lathe bed. The armature is allowed to drain more or less according to the thickness of coating desired. The lathe is then operated slowly to prevent the varnish running and the pan is replaced by the heater. Two pieces of sheet metal are placed, one on each side of the armature, to help confine the heat. The varnish does not drop on to the heater because of the slow rotation of the armature in the lathe.

On armatures for motors up to 20 hp. a temperature of approximately 200 deg. F. is obtained, which requires a baking time of from 10 to 20 hr. according to their size. Larger armatures do not attain this heat and require longer baking. They are usually allowed to bake over night and the night maintenance man inspects them occasionally. This method has its disadvantages but the quality of the work is good.

The advantages of this method are: It has a low first cost; a minimum amount of varnish is required in stock as 12 gal. is sufficient for a 100-hp. armature; the necessary equipment takes up little room when in or out of use; a heavier coat of varnish can be applied as the rotation prevents draining; it makes an even and good-looking job, as the varnish does not sag; the necessary equipment can be made in the shop by almost any good plant mechanic.

Its disadvantages are: Excessive labor cost, as it requires about 2½ hr. per piece except on armatures of 5 hp. and less; the pans must be set up, the varnish has to be taken out and returned to the can each time, the pans must be cleaned out and so on; the cost of heat is excessive, especially if power is purchased; the lathe cannot be used for other purposes while baking. It is our intention to replace this outfit shortly with a dipping tank, an oven and a trolley.

The cost of our armature winding is not excessive, however, as is shown by the data on jobs of three representative sizes. These figures do not include the overhead:

Gen. Elec., 5-hp., 12-pole, Type RD.. 26A, Lathe Wound

Labor cost, including handling	$10.18
Varnish, insulating material, etc.	3.25
8 lb. No. 16 c.e. wire	4.80
Total cost	$18.23

Westinghouse, 10-hp., Type SK 70

Labor cost, making coils	$ 5.67
Labor cost, winding and handling	17.90
30 lb. copper at 60c	18.00
Insulating material, bands and solder—estimated	3.64
Total cost	$45.21

Elwell-Parker, 100-hp., Special Multipolar Crane Motor

Labor stripping, reinsulating coils, rewinding, turning and handling	$52.00
Insulating material, solder and bands	16.80
Total cost	$68.80

Regardless of where the work is done or what the method is, results are what count. My opinion is that

(*Please turn to page 531*)

Fig. 9—All dipping, baking, armature coil winding and banding are done on this lathe.

This keeps the lathe busy nearly 24 hr. a day. How a 40-hp. crane motor armature is dipped is shown at *A*. The bed and legs of this lathe were made in the Machine Shop from a large channel and angle iron. The head and tailstock were taken from an old lathe and blocked up on short sections of I-beams. This lathe is rugged and satisfactory. One of the jobs in the shop when this picture was taken was a 60-hp. G. E. crane motor, the frame of which is shown at *B*. *C* shows samples of spare parts which were made in the Machine Shop. *D* is a telpher trolley pole partly assembled. *E* shows two coil frames and a finished coil. *F* is a wire-reel rack, and a set of field coils which have just been dipped and baked, are shown in front of it. Magnet coils are wound on the speed lathe, *G*, in front of the window. *H* is an armature coil spreader, with a set of coils, and *I* is a portable armature rack.

Summary of the

Recent Changes Made in National Electrical Code

that affect the rules governing installation and protection of equipment, together with revisions which make some rules more easily understood

By G. A. VAN BRUNT
Managing Editor, Industrial Engineer

THE 1925 EDITION of the National Electrical Code, published by the National Board of Fire Underwriters, has been approved as an American Standard by the American Engineering Standards Committee. The biennial revision of the Code was performed by the National Fire Protection Association as the sponsor organization through a sectional committee having 39 organizations represented in its membership, including several Federal, state and municipal bodies, in addition to the various technical, industrial and commercial associations concerned. In this article the more important changes which will appear in the 1925 Code and are of interest to industrial plant men, are enumerated and discussed in detail.

ALTHOUGH no radical changes have been made in the new edition of the Code there are many variations from the 1923 Code. Some of these variations are the result of thorough editorial revisions in the way of improvements in wording or rearrangement of rules to make them clearer, with no change in the intent or requirements of the rules. In consequence the 1925 Code will be more nearly free from errors and conflicting or ambiguous statements. Other revisions are, however, quite important; those which are of particular interest to industrial plant men will be discussed briefly in this article.

In Section 402, a new paragraph c has been added which reads:

> When a service from overhead supply wires to a building is carried underground, the portion of the wires underground and running up the pole to a point at least 8 ft. above the ground shall be lead-covered and suitably protected from mechanical injury.

A new paragraph, e, has also been added to Section 404, covering the service entrance protection of systems operating at more than 600 volts. The new rule states clearly the requirements and optional provisions for the service entrance equipment.

Changes in Section 405 include a new paragraph, a, to the effect that in that section the word switch is to be construed as including a circuit breaker that may be manually operated.

Rule 405 b in the 1923 edition has been expanded into two paragraphs, c and d, in the 1925 Code. The new Rule 405 d 2 reads:

> Where the switch and fuses are mounted in an approved cabinet having no live parts or wiring exposed and capable of being sealed or locked, the switch blade may be omitted in any grounded conductor if other means is provided within the cabinet for disconnecting such conductor.

Another new paragraph, j, reads:

> An automatic overload circuit breaker may be used in place of both service switch and fuse and when not subject to competent supervision shall be of a type specially approved for service conditions.

New Rule 405 l provides that for groups of buildings fed from one service or generating plant, a service switch shall not be required in the building served if the feed to that building is switched at the center of distribution.

Under Section 504, a new paragraph, j, covers combination metal raceways which are designed to afford a convenient means of providing the necessary outlets for both light and signal wires in office and similar buildings.

Under Section 603, Flexible Cords, there is an important exception to paragraph c which reads:

> Exceptions: For Types PO, P and PWP with conductors of No. 18 gauge, the rubber insulation may be 1/64 in. in thickness. When Type PO cord has 1/64-in. insulation its use shall be confined to portable lamp fixtures.

This change will permit the use of armored reinforced cord, ordinary reinforced cord and weatherproof reinforced cord with a minimum insulation of 1/64 in. of rubber on each conductor, instead of the 1/32-in. rubber insulation required by the old Code, and thus allow cords of considerably smaller dimensions than were required by the previous rules, to be used.

A slight change has been made in Rule 701 m covering the use of outlet boxes or plates. This rule previously required the use of such outlet boxes or plates on conduit, metal raceways, armored cable and "concealed work." The words "knob-and-tube work" have been substituted for "concealed work," which expression has gone out of use in the Code. The new rule thus clears up the question of the requirement of outlet boxes on knob-and-tube work.

A new rule, 802 a, limits the use of link fuses to capacities of more than 300 amp. In other words, link fuses in capacities up to 300 amp. are prohibited, which is in line with the trend of development in fuses.

A change in Section 805 e provides that all cutout bases, circuit breakers and fused switches, except when located in approved rooms or fireproof electric closets, shall be enclosed in approved cabinets or cutout boxes, or be so designed, protected, or located that live parts will not be exposed to accidental contact.

In the rules covering general fuse protection, there appears a new Rule, 805 p, which reads:

> A fuse or trip coil shall be placed in every ungrounded wire of all grounded circuits, except as provided for branch circuits in Section 807 of this code.

This new rule clears up a subject which has been the cause of much discussion. It is quite common on three-phase circuits to ground the neutral point of one transformer in order to obtain the lowest potential to ground. The old rule of the Code was sometimes interpreted to permit trip coils in two wires only, leaving one wire without protection against grounding, which was not the intent of the Code rule. The new rule will tend to clear up any misunderstanding on this point.

Several changes have been made in the different paragraphs of Section 807, Fuses for Lighting and

Appliance Branch Circuits. For example, the terms, "Branch Circuit," "Outlet," and "Appliances" have been clearly defined in paragraph a, as follows:

"Branch Circuit"—Branch circuit is that portion of a wiring system extending beyond the final fuse or fuses protecting it. For particular applications to motor branch circuits, reference should be made to Section 808.

"Outlet"—An outlet is that fixed point on a branch circuit at which current is taken to supply fixtures and appliances. An outlet having a fixture with more than one socket attached shall be considered as one outlet. An outlet having a multiple receptacle installed therein shall be considered as one outlet.

"Appliances"—Appliances are current-consuming devices for domestic or general commercial use, such as heating, cooking and small motor-operated devices, etc., suitable for use on 15-amp. branch circuits.

Section 807 b has been revised to read :

All ungrounded wires of a branch circuit shall be protected by fuses or circuit breakers. When the grounded conductor is identified and properly connected, branch circuits shall be protected by fuses in the ungrounded wires only. In locations where the conditions of grounding or the liability of the reversal of connections warrant, the inspection department may require, on systems having a grounded neutral or having one side grounded, that both wires of two-wire branch circuits shall be fused, even though the grounded conductor is identified, and properly connected.

It will be noted that when the grounded conductor is identified and properly connected, the neutral fuse *must* be omitted, although inspection departments are given the authority to require double-pole fusing when conditions warrant it.

A number of changes have been made in Section 808, Protection of Motor Circuits; thus paragraph a now reads:

The conductors of circuits supplying current to a single motor shall have a carrying capacity, according to Section 610 of this Code, which is not less than 110 per cent of the nameplate current rating of the motor.

It will be noted that the qualifying clause, "the actual size to be determined by the rating of the fuses or the setting of the circuit breaker or overload relay protecting them," which appeared in the 1923 Code, has been omitted in the 1925 edition.

Rule 808 b now reads:

Each ungrounded conductor of a circuit supplying current to motors shall be protected by a fuse or by a circuit breaker, except the conductors supplying current to a single motor and which are suitably protected from mechanical injury shall be considered as sufficiently protected by the fuses or circuit breakers next back on the line, if the carrying capacity of these conductors is at least one-third of that of the wires to which they are connected and their length to the motor protective devices does not exceed 25 ft. A fuse or circuit breaker shall not be placed in any permanently grounded conductor supplying current to motors, except that a circuit breaker with one pole in each conductor may be used provided the breaker is so designed that the pole in the grounded conductor cannot be opened without opening simultaneously all of the conductors of the circuit.

This is interesting and important in that under certain conditions it permits the size of wire required for a single motor to be smaller than was allowed in the previous edition of the Code. It comes about as a result of the rule allowing the wire to be overfused 300 per cent. Back of it is the fact that although the starting current of an alternating-current motor may exceed the allowable carrying capacity of the wire, the length of time that this heavy current flows is so short that the heating effect may be neglected. Furthermore, the length of the motor circuit is limited to 25 ft.

Rule 808 e has been revised to read:

The wires in that portion of a motor circuit between a motor running protective device which is shunted or cut out during the starting period and its motor shall be considered as sufficiently protected during the starting period if there is a fuse or circuit breaker back on the line which is rated or set at not more than 500 per cent of the nameplate rating of the motor.

The 1923 Code required that the rating of the fuse or the setting of the circuit breaker should be not over 300 per cent of the motor nameplate current rating.

In Section 811, paragraph a has been revised to permit heating appliances each of 1,320 watts or less to be grouped on a special circuit protected by fuses of not more than 15-amp. rating. Appliances of more than 1,320 watts total capacity must be supplied by a separate branch circuit.

Paragraph b has been amended to provide that individual heating elements of electric heating appliances shall be fused if they are rated at more than 30 amp.

Several revisions have been made in Section 901, Grounding. For example, in paragraph a, the word "objectionable" has been substituted for the word "appreciable." Also, directions for eliminating the objectionable flow of current, in certain cases, have been added, as follows: Where an objectionable flow of current over a grounding conductor occurs due to the use of multiple grounds, one or more of such grounds shall be abandoned or their locations shall be changed.

Paragraph c of Section 901 has been changed to require the use of ground pipe not less than ¾ in. *internal* diameter. The 1923 Code called for pipe not less than ¾ in. external diameter. This paragraph further provides that driven pipe or rods shall be of only one piece when of less than standard commercial length and shall be driven to a depth of at least 8 ft., regardless of the size or number of rods or pipes used.

Paragraph d of Section 902 has also been revised to cover more thoroughly the various types of grounding, especially three-phase systems with one phase grounded at the transformer and at the neutral point. This paragraph now reads:

On single-phase alternating-current systems the ground shall be made at each service on the line side of the service switch before the service is connected to the line. On multiphase alternating-current systems the ground shall be made as described for single-phase systems if the grounded conductor of the multiphase supply system is brought to the premises for rendering service. By permission of the inspection department the grounding connection for either single-phase or multiphase systems may be made on or near the transformer or transformers, or by connection to a system ground wire.

In Section 905, Grounding Conductors, paragraph a has been revised to permit the use of grounding conductors made of metals other than copper, which will not corrode excessively under the existing conditions. Heretofore the Code has required that copper must be used.

Rule 905 c has been changed to read as follows, the additions to the 1923 Code rule being shown in italics:

The insulation and installation of the grounding wire for circuits, when not protected by metallic piping, shall comply with all requirements of this code applying to wires of the voltage of the circuit to which the grounding wire is attached. *When a circuit grounding wire is installed in metallic piping and is bonded to it at both ends, a bare copper conductor may be used.*

The additions shown in italics have also been made to paragraph 905 d: *Ground clamps* and all grounding wires *which are smaller than No. 4 in size* shall be protected from *ordinary* mechanical injury *by being placed where they are not liable to be damaged or by being enclosed in metal, wood or equivalent protective covering.*

As revised, paragraph 905 g now reads:

The grounding conductor for a direct-current system shall have a current capacity not less than that of the largest feeder of the same system leaving the station. In no case shall the grounding conductor be smaller than No. 8.

Paragraph 905 j has been amplified and the size of the grounding pipe specified as shown by the following table:

Capacity of Nearest Cutout Protecting Conductors in Conduit, Armored Cable, Metal Raceway, or Equipment	Size of Copper Wire Grounding Conductor	Size of Grounding Pipe
0 to 100 amperes	No. 10	½ in.
101 to 200 amperes	No. 6	½ in.
201 to 500 amperes	No. 4	¾ in.
Over 500 amperes	No. 2	1 in.

Paragraph m of Section 905 in the 1923 Code has been omitted.

Under Section 1302 a new paragraph, g, has been added which reads:

On switchboards where instruments, meters, or relays operate with windings or working parts, at a potential of 150 volts or above to ground, the cases and other exposed bare metal parts of these devices insulated from the current-carrying parts shall be grounded unless isolated by elevation or protected by suitable insulating barriers or guards or where inaccessible to other than qualified persons, in which case grounding is required only when the voltage exceeds 750. The grounding conductor shall be not less than No. 12. Where instruments, meters or relays are operated from current or potential instrument transformers, the cases and other exposed bare metal parts which are insulated from the current-carrying parts shall be grounded. The grounding conductor shall be not less than No. 12. If exposed to higher voltages through transformer windings or otherwise, secondary circuits of current and potential transformers of less than 750 volts shall be isolated or grounded unless placed in grounded conduit or other suitable duct, or identified and guarded as required for conductors of the highest voltage to which they are exposed. When a grounding conductor is used it shall be not smaller than the conductor of the secondary circuit.

Section 1403, Installation of Fixtures, has been amended to provide for grounding of fixtures. In part this section now reads:

a. Straight electric fixtures shall be grounded except as described in 1 and 2 below.

1. Fixtures mounted on metal ceilings or side walls, or on walls or ceilings containing metal lathing, shall be grounded or shall be insulated from their supports by approved insulating joints or by approved insulating fixture supports, and canopy insulators shall be used.

2. Fixtures in open wiring, knob-and-tube work or wooden raceways and not on metal ceilings or side walls nor on plaster walls or ceilings containing metal lathing need be neither grounded nor insulated.

b. Fixtures shall be considered as grounded when mechanically connected in a permanent and effective manner to metal conduit, armored cable or metal raceway systems, or to a separate grounding wire not smaller than No. 14, or to gas piping which is grounded in the manner specified in Article 9 of this code.

In the 1923 Code grounding of fixtures was optional.

A change in Section 1404 a provides that switch sockets shall be so constructed that the switching mechanism interrupts the electrical connection to the center contact, and shall not interrupt the connection to the screw shell unless the connection to the center contact is simultaneously interrupted. This requirement will not become effective until September 1, 1926.

Several changes have been made in Section 5003, Wiring. For example, in paragraph a the 5,000-volt limit in the 1923 Code for wires installed in or above buildings other than central stations, substations and transformer vaults, has been raised to 7,500 volts. Paragraph b has been revised to require that "Elsewhere than in central stations, substations and generator, transformer, switching and motor rooms, all apparatus and wiring connected to circuits of more than 600 volts shall be completely enclosed by substantial shields or casings," etc.

Paragraph d has likewise been amended and now specifies that elsewhere than in central stations, substations, etc., all wiring of circuits of more than 600 volts shall consist of approved multiple-conductor, grounded metal-sheathed cable inclosed in approved grounded conduit.

Section 5008, Transformers in Furnace Rooms, in the 1923 Code has been made paragraph e of Section 5005 in the 1925 Code and Section 5008 now bears the heading, Static Condensers. The three paragraphs under this section read as follows:

a. Static condensers of the type made up of small units, each of which contains less than three gallons of oil, may be installed in power houses or factory buildings if combustibles are kept well away from them. In rooms containing combustible dust or flying material, condensers shall be inclosed.

If condensers are accessible to other than qualified persons a non-combustible grille or guard around them may be desirable.

b. Condensers which have all units in single tanks filled with oil shall be installed as required for transformers in Section 5005.

c. For transformers used with static condensers, the requirements of section 5005 shall be followed; provided, however, that by permission of the inspection department, oil-filled transformers intended for and used only with static-condenser installations and not subject to lightning disturbances may be installed in rooms of non-combustible construction and occupancy. Such transformers shall be of sufficient capacity to allow for ordinary rises in voltage; they shall be surrounded by concrete curbs not less than 6 inches high which form a basin of sufficient capacity to retain all the oil contained in the transformers; and be protected by an automatic overload circuit breaker (or other protective device and switch) set to operate at a current corresponding to not over 150 per cent of the rated capacity of the condenser.

Repairing Motors and Armatures

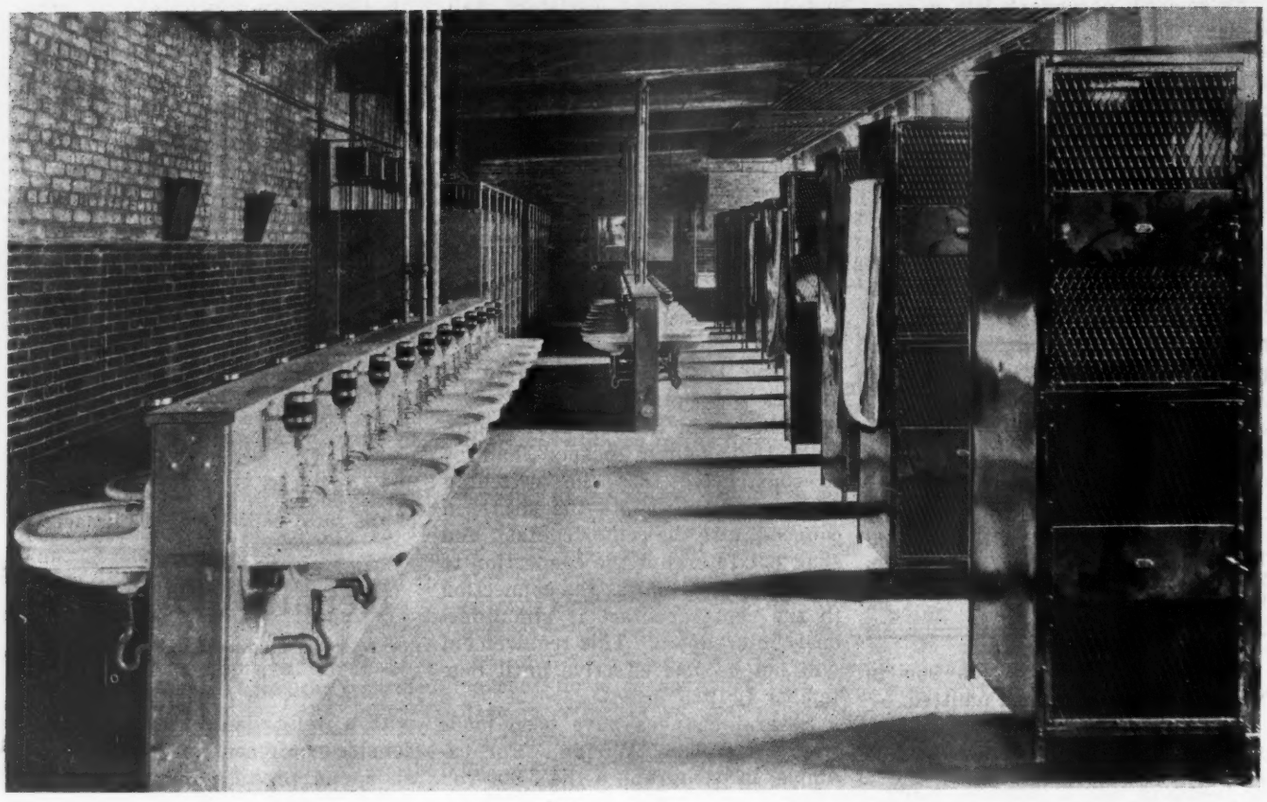
(Continued from page 528)

with a well-organized crew and reasonable equipment, the plant repair shop can produce quicker and far better results than can be obtained from outside work. Also, the shop foreman is much better acquainted than a commercial repair shop could be with the particular problems involved, understands the conditions causing them, the requirements under which the motor will operate and is, therefore, better able to meet them.

I have found that it requires considerable thought and study, as well as close attention to details with some kind of system for following up the work, to solve these problems and I doubt if the average commercial repair shop is willing, or could be expected to devote the necessary time in this connection.

Armature removals for electrical trouble at our plant have shown a steady decrease, on an average, for the past 18 months and, while megger tests of armatures on the job in January, 1924, showed an average of about 1 megohm, tests in the same department during January, 1925, showed, with one or two exceptions, infinity.

These pertinent facts may be taken as a fair indication of the results attainable with this method of procedure under extreme operating conditions. These results, and also the low cost of the work, convince us that the records, which we keep on all work, bear an important part in attaining the results.



This shows a structural slate installation in the washroom of the National Lead Co., Chicago, Ill. The backing, tops and ends of the structure supporting the wash basins are made of slate, as are also the stalls in the back corner of the room.

Things that plant men should know about the

Industrial Applications of Structural Slate

together with money saving ideas in the use of slate, how the various finishes and surfaces are applied, and practical advice on handling and installing it

By FRANK E. GOODING

Associate Editor, Industrial Engineer

SLATE is one of the comparatively few materials that is not affected by moisture and corrosion, and in consequence it finds numerous uses around industrial plants. The use of slate for electrical purposes has been discussed in an article entitled, "Slate as a Switchboard Material," which appeared in the June, 1925, issue of INDUSTRIAL ENGINEER. This use of slate, therefore, will not be covered in this article, except by some comparisons in cases where other industrial uses are the same or differ from electrical uses.

Structural slate is commonly used around industrial plants for shower and toilet stalls, and other sanitary purposes, lavatories, tanks, sinks, vats, laboratory and other special purpose table and bench tops, for trench covers, shelves in packing plants, flagging, for instrument mountings, and, when given special finishes, for wainscoting, window sills, floors, stair treads and other purposes.

Slate is a sedimentary product which was formed from clay under the action of extreme heat and pressure, due to convulsions in the crust of the earth. This original clay was compressed into layers which formed a rock with a natural cleavage which makes it possible to split the slate easily into layers. Slate is found in quarries in Pennsylvania, Vermont, Maine, and some other states, and is quarried in much the same way as other stone. It is removed from the quarry in large blocks which are split along the natural grain into sheets of the required thickness, with sufficient allowance to be finished off as desired.

Slate in general is used for roofing, for miscellaneous purposes, which include its electrical applications, and for blackboards. Slate used for structural purposes is known as mill stock. Such slate must be of a fine, even grain and also must split or cleave smoothly so that it does not require an excessive amount of working to finish the surface. In general, industrial slate comes under two classifications: clear and "ribbon stock." The highest grades of clear slate are used for blackboards and for electrical purposes. For these, as was explained in the previous article, it is necessary that the grain be clear and the slate be free from any impurities which would cause it to be of poor electrical quality or to have natural defects which would not permit its use as a blackboard.

Ribbon stock is so-called because of bands, called ribbons, which run

through the slate. These are caused by layers of clay containing mineral deposits which appear as bands in the slate. However, ribbons in no way lessen the value of slate for most industrial work, except for mounting electrical equipment, and when the slate will be subjected to acids. The methods of finishing slate will be discussed later in the article.

Physical Characteristics of Structural Slate

One of the particular qualities of slate which accounts for its use as a construction material is that it is practically non-absorptive. Tests have shown that it will absorb less than 0.2 per cent of its weight when immersed in water for 24 hr. This makes slate very useful in wet places, and of particular importance in connection with problems of sanitation. Slate weighs approximately 180 lb. per cubic foot.

Although this material is not generally used for purposes that require high compressive or tensile strength, tests show that it is stronger in both of these respects than are many other building materials. In addition, slate has a high degree of toughness as well as considerable elasticity, which enables it to withstand considerable stress without fracture. This quality is of particular value in construction work.

Another physical characteristic which is of considerable importance in industrial work is that slate has practically no expansion and so can be used for mounting instruments and for purposes which involve its subjection to heat or cold. Also slate is relatively highly resistant to abrasion and so can be used for floors and stair treads.

A factor of particular importance in the use of slate is the desire of manufacturers to standardize on certain sizes for definite purposes, such as for showers, toilet enclosures and so on. In this way they can manufacture slate for storage and not have to wait for special orders before beginning production. A slate manufacturer does not devote all his efforts to one type of product. It is necessary that he manufacture all types of slate products as it is only in that way that he is able to use up the larger share of his production; even then, approximately 75 per cent of the slate quarried is wasted.

It is impossible to quarry slate and stock it to be worked up on order, because after slate is exposed to the air for a short time it hardens and does not split as evenly or easily as when first quarried. Therefore, if users will purchase slabs of standardized size, they can profit by the economies which the manufacturer can make in production. Otherwise the slate has to be quarried, cut and finished to suit each individual requirement.

It is also to the user's advantage to specify and accept ribbon stock whenever it is possible to use it. Ordinarily, even in the best quarries, only about 20 per cent of the slate is clear stock and as it is absolutely essential to use such stock for electrical purposes and for blackboards, its cost is from 25 to 30 per cent more than for ribbon stock. The ribbons have no bearing upon the strength or other physical properties, other than electrical resistance, and as ribbon stock is so much more plentiful than the clear stock it is also cheaper and is, therefore, considered as standard for most purposes, unless clear slate stock is specifically required.

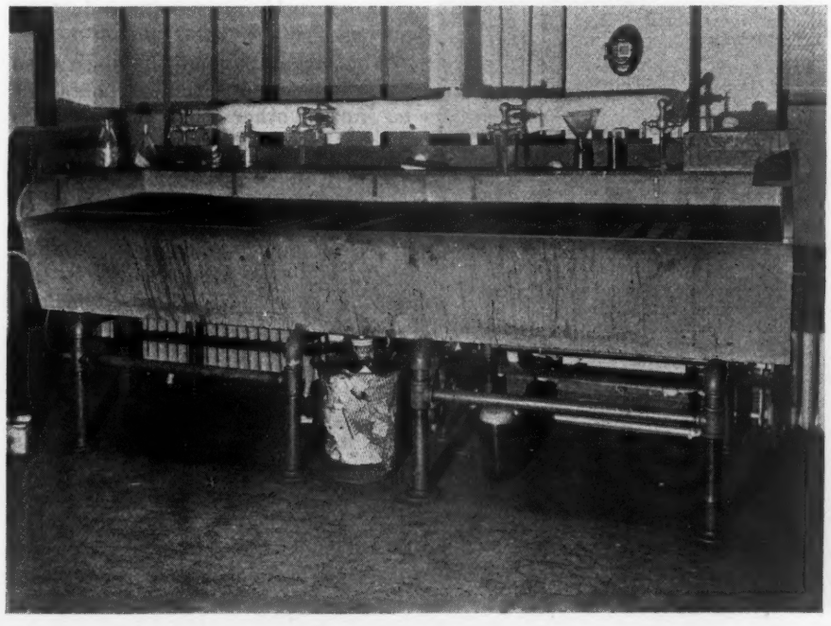
MISCELLANEOUS construction work around the industrial plant calls for the use and installation of various materials with which the plant man may have had little experience. Slate is one of these materials which is widely used, but it is frequently installed when the plant is built. However, the industrial plant man is required to make any changes and additions to the existing installations. Some of the industrial applications of slate, together with a discussion of its origin, the methods of preparing it for use, finishes, grades and suggestions on its use are given in the accompanying article.

Some of the Special Surfaces and Finishes Given to Slate

A knowledge of various commercial finishes and surfaces in which slate may be obtained is useful in that this knowledge will insure proper selection of the surfaces and finishes best adapted to and most economical for the purpose for which the slate is to be used.

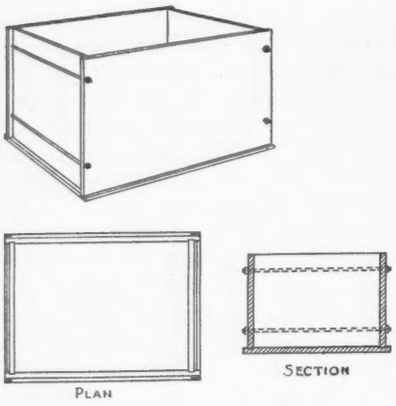
The term "sawed edge" indicates that the edge of the slab is left rough, showing the saw marks resulting from cutting the rough slab to the desired size. Sawed edges are confined to slabs up to 6 in. wide, which are particularly adapted to making window sills, edges of wall copings, straight nosing of outside steps, and concealed edges where no finish is required, and similar construction. If a sawed edge is not desired, the next choice of edge finish is the standard sand-rubbed surface.

The various surface finishes



This two-compartment acid and washing tank is made of slate.

The floor is also made of slate tile set in concrete. Slate is not affected by most acids, has very little expansion, and is not affected by heat or cold. This makes it a good material to use in the construction of tanks and vats. This is a two-compartment tank; the sides are made of two pieces of slate which join at the division separator slab. Because slate does not expand or contract with changes in temperature, the cement does not work loose in the joints as might otherwise be the case. This illustration was taken of a recent installation in the engraving department of a Milwaukee, Wis., newspaper plant.



This is one method of constructing slate vats.

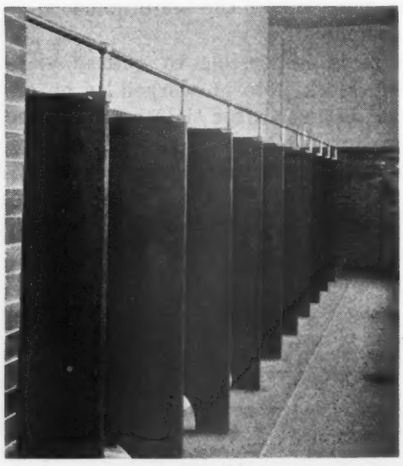
Slate vats used in tanneries or other manufacturing establishments are, if of large capacity, usually constructed as shown in the accompanying drawing. The slabs vary in thickness from 1¼ in. up and the sides and ends are let into the bottom and into the sides. The sides project beyond the ends and long bolts with nuts are used to make a rigid construction. In the construction of smaller slate tanks the bottom and ends are let into the sides and set in waterproof cement.

which may be obtained will be discussed in the order of their manufacture. Split-face surface is the surface left as the result of the first splitting of the slate into the thickness desired and before the slate has gone to the planer. It is a fairly rough surface somewhat similar to a rough grain, although comparatively even, straight, and true in plane. This is the surface generally left on slate roofing and is also used in some cases for architectural effect, and for some outdoor uses of slate. Split-face surfaces should also be specified where a smooth finish is not necessary or where the surface is concealed, as in the back of wainscoting bases, blackboards, the underside of floor slabs and similar places.

The next surface supplied is a "planed" surface, which is obtained by passing the split face of the slab through a planer. The plane marks show faintly and so this finish is used for the back of switchboards and for the underside of stair treads, landings, risers, and wherever absolute uniformity of finish is not essential, but where a straight, smoothly planed surface is required without the roughness of the split face. The standard sand-rubbed finish, which is the next and most common finish used, is obtained by taking the slabs from the planing machine and placing them upon large revolving metal disks where they are rubbed smooth under the action of sand and water. The result is a uniformly smooth, even surface, having a very slight grain or stipple. This is the standard surface supplied on slate for sanitary uses, as well as for wainscots, bases, stairs, flooring, tanks, vats and other purposes.

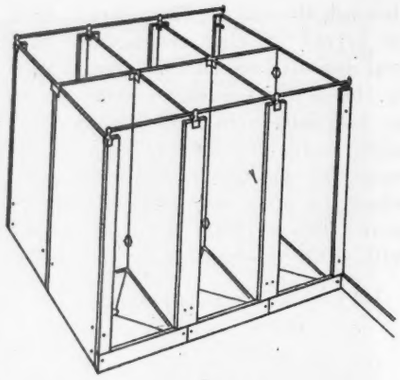
The next and final surface, which may be obtained at an additional cost, is called "honed finish." This can be applied to the surface of slate for any intended use, but in some cases it is not desirable and in others the increase in the cost over the standard sand-rubbed finish would not be justified. If it is desired, however, for any type of installation where the sand-rubbed finish is standard, the honed finish can be furnished, but only when distinctly called for and at an added expense.

The honed finish is finer and smoother than the standard sand-rubbed finish, although the mistake is often made of confusing the two. This finish is produced after the sand rubbing by an additional honing or polishing process. Both finishes produce a similar, perfectly smooth polish, which is the nearest approach to a high gloss that can be given to slate. The honed finish is not a necessary or suitable finish to be given where the slate is to be subjected to the abrasive action which floors, stair treads, and thresholds receive. It is applied only in special instances where a smooth finish is desirable or where it is standard for particular uses, such as for electrical panel boards and other special surfaces.



An economical and effective type of construction for stalls.

Here the lower back corners of the slate partitions are cut away so as to make it easier to clean around them by eliminating the corners, which are so difficult to get at. The legs on which these partition slabs stand are set about an inch into the concrete floor. The tops are held stationary at the upper corner by the pipe rail and fittings, as shown. This installation was made of ribbon stock. The ribbons do not affect the usefulness and serviceability of the material except where it is subjected to acids or is used for electrical purposes. A sand-rubbed finish with an application of oil is the usual finish for such installations as this.



One type of construction for shower stalls.

In this type of installation the slate backs, ends, and partitions are continued to the top of the floor slabs. Other and cheaper constructions are made by leaving off the front stiles or curb at the bottom, or both. The standard curb at the bottom is 6 in. high and the backs, ends, partitions, stiles, and curb are 1 in. thick. The floor slab is 2 in. thick and slopes to a drain in the center of the slab. Frequently lead pans are used under this floor slab. These showers are made in a standard height of 6 ft. 6 in., in two standard widths of 3 ft. and 3 ft. 6 in., respectively, and a standard depth of 3 ft. 6 in.

In addition to the polished or finished surfaces which are ordinarily applied to the slate, there are numerous other finishes which may be applied as ordered. These are generally known as enamel and marbleized finishes. It is possible to give slate a black or white baked enamel finish and also special marbleized finishes which imitate most of the high-quality marbles. These, however, are seldom used for industrial purposes.

The larger part of the slate used for various industrial purposes has no finish other than the surface placed upon it by mechanical processes in the mill, such as the sand-rubbed or honed surfaces. Under ordinary wear and tear of erection, there should be no damage to the surface, due to the strength of the slate. After erection, therefore, no more mechanical work is necessary to finish the edges or faces, such as is often the case with softer and more decorative stone. When an installation of slate is in place it is, however, customary to put some finish on the surface which will not only clean the slate, but will bring out its color and make the slabs more uniform in appearance. One of the most common of these is known as

the oiled finish and is almost universally used, except on enameled or marbleized slate, although other finishes may be applied.

The oil finish is obtained by applying raw linseed oil with a brush or cloth. The oil may be thinned with turpentine if it is desired to apply a lighter coat or it may have lamp black added which makes it black in color. This is the finish specified as standard in nearly all specifications. It does not show ordinary dirt and if at any time it needs freshening, another light application of the oil or oil and lampblack will bring back the finish. This finish is particularly effective on slate switchboards, as was mentioned in the article in the June issue of INDUSTRIAL ENGINEER, and is particularly adapted for use on any installation that is subject to oil splashes.

Oil finish should also be used on toilet or shower stalls and other sanitary installations, for wainscoting and, in general any industrial construction where slate is used for purposes other than its decorative effects. No finish, however, is applied as a rule on stair treads, floors, exterior slate copings, walls, and so on.

The black marine finish gives a moistureproof surface which has the peculiar quality of causing all water on it to evaporate quickly. It is a long-lasting finish of good appearance and is called for frequently in electrical specifications where there is danger of moisture. This finish is produced by applying amylacetate lacquer, colored with black aniline dye, which makes the slate a jet black color. It may be used industrially instead of the oiled finish, but is more generally employed on electrical installations.

The stripes or bands in this slate are due to the "ribbons."

Slate was formed from clay deposits under the influence of heat and pressure. Mineral deposits in the original clay show up as a streak or ribbon in the finished slate. These ribbons do not affect the value of slate for most industrial purposes; clear stock, that is, stock without ribbons, must, however, be used for all electrical installations or where the slate is subjected to acids.

Aside from the oil finish, the most common finishes used on installations of slate in industrial plants are produced with paints or stains. One of the characteristics of slate is that stains and paints adhere to it very firmly. Therefore, it is possible to secure a variety of different effects by the use of stains or wax, which should be applied and rubbed in with a cloth.

If any special tints or colors are desired upon slate stalls, partitions, and so on, lead and oil paints may be used. This painted finish may be applied in the same way as on any metal or stone, although it is recommended that not less than three coats be used and preferably four. The best quality, pure white lead, linseed oil and tint should be used. Experiments have also shown that the Duco lacquers, which are commonly used on automobiles, give very satisfactory results on slate. For most sanitary installations, the oil finish is used on all exposed surfaces. It should be remembered that these finishes are applied after the installation is made, and on a sand-rubbed surface, which is the finish given to the slate by the manufacturer. Unexposed surfaces are commonly left with a planed finish, although sometimes, if set in concrete, are left with a split surface.

When erecting any structural slate it is frequently necessary to drill extra holes. The need of this is minimized if standardized dimensional units are purchased as these are drilled by the manufacturer or, if sufficient planning ahead is done, all necessary holes are drilled according to the specifications given to the manufacturer.

Drilling a hole in slate, however, is not a difficult nor long job, if properly done. If an attempt is made to use a fairly large drill it will usually be difficult to drill straight through. It will invariably sheer off to one side, due to the hard veins in the slate. The surest way to get the hole where it is wanted is to first drill all the way through with a small drill, about ⅛ in. in diameter. This small hole will guide the large drill and allow it to cut faster, as its point has no obstruction to cut through.

Drills for slate should be sharp. Use the small sizes in a small geared hand-drill and the sizes above ⅜ in. in a common carpenter's brace. The small hand-drill should be worked very fast and under comparatively light pressure, but the larger drills should be worked slowly and with greater pressure. The drills will ther retain their sharp edge and will not neat, but will cut rapidly and cleanly.

Drilling slate at high speed and attempting to cool the drills with water is not good practice as the drills will heat and lose their temper, and the slate dust will form into a thick mud almost at the start. Care should be taken to ease up on

(*Please turn to page 554*)

Here is another case where a slate floor and vats or tanks for acids are giving good service.

The floor is made of sand-rubbed slate and the acid tanks have the same finish. Slate flooring is not affected by the acid that may be spilled on it.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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Chicago, November, 1925

Let a Notebook Remember Things You Want to Do

MUCH of the planning of future work and of changes that should be made in departments or in equipment, is frequently "carried in the head" of the operating man. Many times the execution of a good idea must wait until a department is closed down temporarily or a machine is out for repair. The man who relies wholly upon his memory to recall these good ideas will often find that he has not remembered them until too late, and the good idea must then be held over until the next opportunity. By that time it is, altogether too often, forgotten entirely.

Operating men who keep and use notebooks, in which these new ideas are jotted down as they occur, find that by occasionally going over their list of "things to do," they can refresh their memories sufficiently so that the intention is very likely to become a reality when the opportunity offers.

Keeping a notebook has the further advantage that ideas which, although they may appear to be excellent at first thought, do not stand up under the scrutiny of repeated readings, are more likely to be discarded rather than carried out—and regretted later.

More Light Means More Production

WITH the approach of winter, shorter days make production increasingly dependent upon the lighting system. In spite of this undeniable and important fact, more than half of a total of 390 typical industrial plants investigated were considered to be poorly lighted, according to a recent issue of *Light*, the monthly publication of the National Lamp Works of the General Electric Co.

This investigation covered from three to over a hundred plants in each of 12 different industries and showed that 15 per cent were classed as well lighted, 29 per cent as fairly lighted, and 56 per cent as poorly lighted.

What poor lighting is costing the average industrial plant, and the advantages which result when the lighting system is improved, are also well shown in this same publication in the tabulation of the results of tests made on old and new lighting installations in nine different industrial plants. These tests showed that an average increase of 15.04 per cent in production was obtained when adequate lighting was provided, at an average additional lighting cost of 1.96 per cent of the payroll. The lowest increase in production in the nine plants was 4.4 per cent at an additional cost of 0.6 per cent of the payroll, while the highest increase in production was 35 per cent at an additional lighting cost of 5 per cent of the payroll. These tests were made under actual operating conditions in factories before and after an adequate lighting system was installed.

In addition to the increase in production, good lighting yields returns in the way of decreased accident hazards, reduced spoilage, less labor turnover, and other advantages which are difficult to reduce to a dollars-and-cents basis, but are of considerable consequence in industry. Where the advantages of an adequate lighting system and the comparatively low cost of installing it, are fully understood, there is little excuse for the 56 per cent of poorly lighted plants remaining in the unenviable classification in which they now stand.

It is not too late to check over the lighting system in your plant and put it in a higher classification if necessary. The increase in production may go a long way toward repaying the cost of better lighting before the winter is over.

Put Broom and Paint Brush on Your Payroll

THE superintendent in charge of a number of food products plants belonging to one organization recently said that he had in several instances been able to increase production 25 per cent or more simply by cleaning up the plant and giving everything a fresh coat of paint.

It might not be possible to duplicate these same results in every industrial plant, but concerning the value of painting up and cleaning up there can be no dispute. Many plants have found that good housekeeping pays large dividends; and, measured in terms of the payroll or value of the product made, the cost is comparatively small.

A clean, orderly plant means much more than the possibility of walking around freely, without danger of falling over materials and parts scattered over the floor. Cleanliness and orderliness strengthen the morale of the workers and tone up an organization in ways whose value is hard to estimate in dollars and cents. Taken by and large, workmen will do more and better work, equipment will be kept in better condition, and the activities of the plant as a whole will be conducted on a higher plane of efficiency in a plant where housekeeping is properly organized than in one where this is not the case.

Soap and water, and paint, do not cost much, either to purchase or to apply, but when they are used consistently they are an effective means of securing results that are hard to obtain in any other way.

Have You Any Hard-to-Heat Spots in Your Plant?

INASMUCH as the cold weather season is almost here, special attention may well be given to those difficult-to-heat places around the plant. Nobody denies the need of heat at these places; the only difficulty is in selecting the best method of heating.

As a case in point, the electrical storeroom of a large steel plant was located at one end of a rolling mill building. It was difficult to use steam heat efficiently in this location; hence for several years a coke salamander was placed by the stock tender's desk to warm him between trips after material. Of course, this was a serious fire hazard, but not until a small fire occurred did anyone think to build a small shanty in which were placed a few electric space heaters. This reduced the cost of the heat and eliminated the fire hazard.

In a clock house at this same plant, a large amount of steam was used for heating the large room where the men punched their time cards. Investigation showed that heat was needed only to keep some of the clock house equipment from freezing. Space heaters were installed close to the equipment involved, and the steam was turned off from the clock house, at a saving that was well worth while.

Unit air heaters properly placed often solve the problem of getting additional heat, during the coldest weather, in the central parts of repair shops and other buildings that have large open work spaces that must not be obstructed with steam coils or radiators. The difference between a warm and a cold repairman is often the difference between whether the equipment he is repairing does or does not stand up in service the way that it should.

Each heating job must be considered by itself and carefully analyzed to determine what form of heating should be used. Plant men are always looking for places to save kilowatts, steam power, and other forms of energy. Why not investigate the possibilities that may lie in the plant heating system?

Keep a Copy of the Code on Your Desk

THE biennial revision of the National Electrical Code has recently been completed, and in the article beginning on page 529 of this issue the most important changes of interest to industrial plant men have been outlined and briefly discussed.

The Code, as it is familiarly called, was first drawn up in 1897 as a result of the united efforts of the various insurance, electrical, architectural and other organizations which recognized the need, from various standpoints, including fire risk and personal injury hazards, for greater standardization in the installation of electrical equipment. In the compilation and frequent revisions of the Code, nation-wide sources of experience and practice have been freely utilized, so that while inventive genius is encouraged and economy fostered, what is considered to be a suitable factor of safety is always retained. Largely as a result of adherence to Code rules, modern practice in the installation and operation of electrical equipment reduces to a minimum the potential hazards incidental to the operation and use of such equipment.

Thorough knowledge of Code rules is a valuable asset to every executive who is concerned with the installation or operation of electrical equipment, and may serve to prevent costly mistakes and regrettable accidents. Further, as a reference work the Code contains dependable answers to many puzzling questions as to what is the safe procedure under given conditions.

Copies of the National Electrical Code may be obtained from the National Board of Fire Underwriters, 76 William St., New York, N. Y.

One Man Should Be Responsible for Plant Operation

NOT many years ago the plant electrical department consisted of one man whose job was more or less of a part-time proposition. As the application of electric power to industrial processes became more varied and widespread, the part-time man became an electrician foreman with a gang of men, all of whom were considered as a part of the mechanical department of the plant.

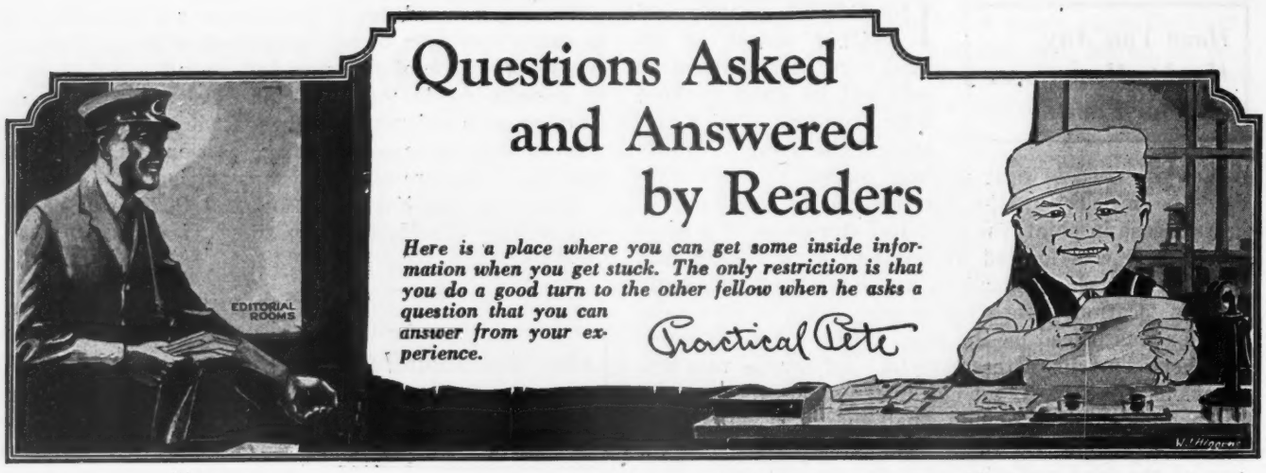
At the present time most of the medium-sized and larger industrial works have a separate electrical department under the supervision of an electrical superintendent. This man divides with the master mechanic or mechanical superintendent the responsibility for the selection, operation and maintenance of all power supply and power drive equipment, as well as the equipment for furnishing light, water, steam, heat, compressed air, and the like. This division of responsibility, however, has its disadvantages. As W. S. Hall, Electrical Engineer of the Illinois Steel Co., says in a recent issue of *Iron and Steel Engineer*:

> Experience has shown that where the control and motor are properly applied, electrical troubles which have developed are generally caused by faulty mechanical design or maintenance in the apparatus which the motor drives. It is, therefore, of the utmost importance to have close cooperation between mechanical and electrical maintenance men. So important is this that considerable progress has been made toward developing men with both mechanical and electrical experience. The question of divided responsibility will always be present until such time as both mechanical and electrical supervision are under one man. This practice is being adopted more and more, as fast as the experienced men can be developed, and it is felt that it is the only solution of the maintenance problem.

This man will be a new type; he may be a mechanically-trained electrical man, or possibly an electrically-trained mechanical man. He will be distinguished by various names; he may be known as a maintenance engineer; he may be called superintendent of maintenance or, as is the case in two large steel plants in Ohio, he may have the title of superintendent of mechanical and electrical departments.

Whatever his title, he must be broad-gauged and able to give operating problems well-balanced consideration from all angles. He will not think of a power drive as being a control and a motor with a thingamajig on the end of it to connect it to the machine it drives, nor yet as a machine driven through a reduction gear and flexible coupling by an electrical contrivance that the other fellow can worry about. He will know the essential details about both the mechanical and electrical elements of these drives, together with all the ins and outs of general plant operation and maintenance.

Are you fitting yourself to be that man in your plant?



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer These?

How to Make a Magnet Recharger—I wish to build a coil for recharging or remagnetizing magneto magnets. This coil is to operate on 230 volts direct-current. I shall be glad to get any information regarding dimensions of core, turns and size of wire, and so on, that other readers can give me.
Somerset, Pa. G. G. F.

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How to Support a Mule Stand.—We are planning on a lineshaft installation in which it will be necessary for the shaft to extend across the room, with an additional section to be installed at right angles along the side wall. We have been considering using a mule stand but some of our men who have had experience with this device in other shops advise going to the expense of separating the shafts and using two motors.

I should like to know the methods other readers have used in supporting such stands and lubricating the pulleys and the results they obtained. This is a mill-construction building with a 2 15/16-in. main shaft and a 1 15/16-in. shaft on the extension.
Milwaukee, Wis. R. C. A.

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Proper Babbitt for Armature Bearings—I would like to learn the experience of other readers as to what kind of bearing metal they find to be most suitable for armature bearings. Is a lead-base babbitt best suited for armature bearings of motors, which are geared direct to the driven machine? With what type of bearing metal do you get the best results on armatures that are direct-connected or belted to the driven machines? There are on the market a great many varieties of bearing metal, including babbitt and various bronze alloys, and I shall appreciate any information that you can give me regarding the selection and application of such metal for use in armature bearings.
Pittsburgh, Pa. H. D.

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Low-Voltage Generator Will Not Excite.—It was necessary to rewind the shunt field coils of a 50-volt generator of very low capacity, which is direct-connected to a small motor having a speed of about 4,000 r.p.m. It is a two-pole machine having 2,000 turns of No. 37 wire in each shunt field coil. When the winding was completed, the machine generated 55 volts satisfactorily. It was then found necessary to reverse the generator position with regard to the motor, which of necessity reversed the direction of rotation; due to this reversal of rotation the residual magnetism of the generator was lost. When I separately excite the shunt fields from a 50-volt, direct-current bus the generator develops its proper voltage. When I reconnect the fields to the armature terminals I get a reading of only 1 volt. I wish some reader would tell me what is wrong and how I can correct this trouble.
Stamford, Conn. W. E. H.

Calculation of Rotor Winding for Squirrel-Cage Motor—I have a 1-hp., 220-volt, Type RI, single-phase, General Electric motor, which I wish to rewind for three-phase operation. I have calculated the winding for the stator, but do not know how to go about figuring the squirrel-cage winding for the rotor. Can any reader give me some help in this matter?
Oakland, Calif. B. B.

• • • •

Measurements Required for Bending Conduit.—When bending conduit by use of a hickey, what measurements should be taken for making an offset, so that I can bend several conduits and have them match when placed side by side? I find it hard to get both sides the same on a double offset. Can some reader tell me how I can make a good-looking job by the use of a hickey on this kind of bending? If any readers have other devices or methods for making double bends and offsets I should like very much to know about them.
Worcester, Mass. R. S. T.

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Effect of Turning Rotor on Split-Phase Motors—I recently had to make repairs on some split-phase motors, and found it necessary to turn down the squirrel-cage rotors. I wish some reader would tell me what effect this would have on the motor characteristics, such as speed and capacity? Also, can some reader tell me how to reverse the direction of rotation on shaded-pole type motors? What is the rule for determining the direction of rotation on such motors?
Hood River, Ore. V. G. W.

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What Is Wrong with the Method of Rewinding This Armature?—I have a Willey electric drill, serial No. 20063, 110 volts, a. c., 6 amp., Type 4 U. C. 2, which is manufactured by the James Clark, Jr., Electric Co., Louisville, Ky. The armature has 17 slots and 32 bars, and is wound with No. 23 cotton-covered enameled wire, using 13 turns per section, with a coil span of 1 to 8, and the leads checking straight out. The armature is hand-wound, left-handed, with the commutator to the right. The only change was that I rewound it right-handed instead of left-handed. I expected that the motor would reverse its direction, which it did. When the drill was connected to the line, both brushes sparked badly, which convinced me that they were off their neutral position. I moved the brush holder to different positions around the commutator, but could not find the neutral point. I took the brush holder head off and checked the leads, which were O. K. Finally the armature was stripped and rewound the same way as before except that I changed the span of the coil from 1 to 8 to 1 to 9. Without moving the brush holders from the position set at the factory, the drill operated perfectly. Why would this armature not operate with the coil span 1 to 8 and wound right-handed? Would winding this armature right-handed instead of left-handed have any effect besides reversing rotation?
Richmond, Va. H. F. S.

Answers Received To Questions Asked

Will Flexible Couplings Reduce Gear Shock on Motors?—I would like to obtain the views of some of our readers on the value of a flexible coupling in preventing the shock and vibration of gears from reaching the motor armature and commutator. We have encountered some trouble from vibration and gear shock affecting commutators and I am wondering if flexible couplings between the motor and the gear drive would help me in eliminating this trouble.
Omaha, Neb. M. P.

Replying to M. P.'s question, I have used flexible couplings on all kinds of drives, including small and large centrifugal pumps operating at 1,750 r.p.m.; also on geared hoists of 100 to 300 hp. operating at 400 r.p.m. and having straight and herringbone gears, with satisfactory results. Several have been in continuous service for nine years without any repairs. I have also had good results in using cloth pinions (made up under various trade names) for absorbing the shock on motor shafts of small and large geared reciprocating pumps, deep well pumps and other heavy equipment. The character and conditions of load, with reference to speed and location of motor, would be the deciding factor in favor of the flexible coupling or silent pinion.

WILLIAM J. MILDON.
Supt. Power & Equipment,
Madeira Hill Coal Mining Co.,
Philipsburg, Pa.

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Treating Windows to Prevent Glare.—I would like to obtain the experience of other readers in treating windows to prevent glare from the sun, particularly on western exposures during the late afternoon. At times this is almost unbearable in parts of our shop. What treatments, if any, have other readers found satisfactory; or would it be better to use shades and, if so, what kind?
Des Moines, Iowa. D. J. C.

With reference to the question recently asked by D. J. C., it will not be necessary for him to use shades to eliminate the glare from the sun.

Proper treatment with a window coating will in most instances entirely eliminate the glare. Ordinary whiting or white wash is sometimes used, but if a study were made of the results obtained, this type of coating would not be considered desirable.

Mr. J. J. McLaughlin of the Illuminating Bureau of the Westinghouse Lamp Co., states that white surfaces

reflect 82 per cent of the light, green 70 per cent, yellow 67 per cent, red 20 per cent and blue 15 per cent. From these figures it is evident that blue would be the most desirable color for a coating.

The material should be one that is easily applied, will not rub off under ordinary conditions and yet can be easily removed if necessary. A product which meets these requirements is being sold on the market today.

Park Chemical Co., Cincinnati, Ohio. A. J. LODDER.

* * * *

Contactors Will Not Close on Low Voltage.—We are having trouble with the contactors failing to close due to low voltage on one of our automatic control panels. The panel is fed from a 220-volt supply, but when the voltage drops considerably the operating coils of the contactors are not strong enough to close them, thereby leaving an open magnetic circuit which causes the coil to roast out. It is rather difficult to provide the correct voltage at this panel all of the time. Can any reader suggest something that I might do to the contactor coil that would enable it to take care of the low voltage condition?

Omaha, Neb. M. P.

In answer to M. P., I would suggest that he try shortening the air gap of the contactors that will not close on low voltage. Quite often there is some means provided by the manufacturer for the adjustment of this gap between the armature and the magnet core of the contactor. If there is, M. P. should find it and use it.

In case no such provision has been made, a little ingenuity on his part should enable him to effect a reduction in this air gap so that the contactor will surely close on low voltage. This adjustment will, of course, make the contactor go in with quite a bit of force when the voltage is up to its full value. If this is objectionable it will be necessary to rewind the contactor coil, which is a job to be referred to the manufacturer.

Gurney Elevator Co., New York City. J. M. WALSH.

* * * *

How to Determine Horsepower of a Shaft or Clutch.—Manufacturers of couplings, clutches and other transmission equipment rate their equipment in horsepower per 100 r.p.m. Thus a device that will transmit 10 hp. at 100 r.p.m would transmit 25 hp. at 250 r.p.m. I understand clearly that the horsepower per r.p.m. is the same in both cases. However, it seems to me that the shock to both clutch and lineshaft caused by operating a clutch at 250 r.p.m. would be so much greater than at 100 r.p.m. that a heavier clutch would be required.

I should like to get the opinions of readers on this point. In particular I should like to know what allowances, if any, they make for clutches and other power transmission equipment operating at speeds higher than 100 r.p.m

Grand Rapids, Mich. E. E. H.

Our experience in determining the rating of power transmission equipment, as asked by E. E. H., has been that over ordinary ranges of speed up to 350 to 400 r.p.m., on many drives, the element of shock does not enter far into the question of clutch selection, and that horsepower ratings are nearly proportional as far as securing results goes.

However, the inertia and acceleration of a considerable amount of machinery are important factors and must be allowed for, in higher speed work, above 300 r.p.m., which may be what E. E. H. has in mind. I think most clutch makers append such a caution to their tables and it is very necessary to take this into consideration, since the inertia of rotation of a line of shafting quadruples with double the speed. Due to the careless way some operators throw in clutches, something is likely to go at the higher speeds.

Our clutch-driven machinery is all very heavy and our men are carefully trained to slip the clutches and pick up speed on the driven end before plugging them in.

Where clutches are used frequently, that is several times a day or oftener, I would recommend using a clutch of one-third to one-half greater horsepower rating, in order to give longer life with reasonable wear.

I am sorry that I cannot give E. E. H. more definite figures, but our estimate of the horsepower on each clutch is pretty much of a guess, although it makes out fairly well, as far as service and lack of trouble go.

Plant Engineer, New Haven Pulp & Board Co., New Haven, Conn. H. D. FISHER.

* * * *

In regard to the question asked by E. E. H., there is some difference in the way manufacturers rate different kinds of transmission machinery, such as lineshafts, clutches, gear reductions, belt drives, bearings, flexible couplings, and so on.

It makes little difference, however, whether such operating devices are rated in horsepower per 100 r.p.m. or in horsepower per r.p.m. The main things to keep in mind are the normal and maximum horsepower to be transmitted by a given drive; the normal and maximum operating speeds for that drive; whether it is to be operated intermittently, for 8 to 10 hr. daily service, or for continuous service, 24 hr. per day; whether it is subject to any shocks and vibrations; the general nature of the installation; and what kind of operating attention it is likely to receive after it is installed.

Much of the transmission machinery installed in the usual small machine shop drives, up to perhaps 25 hp. or 50 hp., is for the purpose of transmitting relative motion rather than for any real or definite amount of power. The starting load or the occasional maximum power requirement may call for a certain motor size, yet in normal operation only half or even one-third of this power may be needed. If the shafts, bearings, pulleys, belts and clutches are adequate for the maximum requirement, it makes little difference whether they operate at 100 r.p.m. or 250 r.p.m., the latter being somewhere near the average operating speed for such drives.

It is usual practice to double the size of equipment for shock loading, such as when a gas engine is used rather than an electric motor, and of course some allowance should also be made because of the nature of the driven machines, such as whether they require a continuous input of power or whether they are intermittently loaded, as in the case of punch presses, and so on.

Take, for example, the simplest kind of transmission machinery—a piece of shafting. Most manufacturers give the highest rating to a given shaft when it is used for the simple transmission of power without any bending strains or shocks; they recommend about two-thirds of this rating for lineshafts subject to usual conditions of bearings about every 8 ft., and with pulleys giving side strains or small bending moments; however, they recommend only about 40 per cent of the first rating for headshafts, gearshafts and other shafts subject to heavy bending stresses. The capacity ratings of such transmission shafts are generally given from 50 r.p.m. up to 500 r.p.m. in the smaller sizes, the usual or average operating speeds being perhaps 200 r.p.m. The larger sizes are usually tabulated for operating speeds from 50 r.p.m. to 200 r.p.m., not a very wide range.

The shafts of electric motors are generally about seven times as powerful as shafts for the simple transmission of power without bending stresses. For example, 1⅞ in. transmission shafts are rated for about 3 hp. per 100 r.p.m., while a 7½-hp., 1,800-r.p.m. (or 5-hp., 1,200-r.p.m.) motor shaft is generally about 1¼ in. in diameter. This is at the rate of only 0.4 hp. per 100 r.p.m.; 3 divided by 0.4 gives an additional safety factor of over 7. Larger motor shafts are generally required to give the necessary rigidity to the drive, to provide adequate area for the bearings, and to take care of shocks and bending moments where pulleys, gears or chain sprockets are mounted directly on the end of the motor shaft.

The crank shafts of Diesel engines are proportionately somewhat larger than motor shafts because of the shock loading and heavy bending stresses, even for the same average torque rating.

It will be seen, therefore, that there are conditions even as important, if not more important, than the matter of operating speeds that govern the size of as simple a piece of equipment as a shaft is generally considered.

When it comes to the question of capacity in relation to operating devices such as flexible couplings for direct-connected and geared drives, the basic calculation for size is made upon the torque capacity of the coupling. One must also consider the operating speed, whether the coupling is going to operate at perhaps 10 or 50 r.p.m. on the low-speed side of a reducer drive, or whether it is going to operate at perhaps 600 or 1,800 r.p.m. on a motor drive, or perhaps 3,600 r.p.m. on a turbine. One must also consider the nature of the connected machines, such as whether the loading is smooth and not subject to shocks and vibrations, as a motor-driven contrifugal pump; or whether the coupling is subject to heavy and continuous shocks and pulsations, for example, when a Diesel or internal combustion engine is directly connected to an ammonia compressor.

The range of direct-connected and geared drives, where a flexible coupling can be economically employed to insure against operating troubles due to accidental shaft misalignments, is very

great. In our catalog ratings of Francke flexible couplings we list the theoretical ratings to give certain material stresses and certain bearing pressures which we have found by calculation and by years of experience to be correct for maximum conditions on absolutely smooth torque drives. By a system of "Service" or "Operating Factors," we reduce these capacity ratings by an amount sufficient to take care of the usual peak overloads, to take care of shocks and vibrations, and to take care of the usual operating conditions incidental to motor, turbine and engine drives when these are connected to many different kinds of ultimately driven machines. The use of the proper service factor is just as important as the basic calculation of machine horsepower rating in relation to the operating speed.

We do make some allowance for the operating speeds, as for instance in the case of rubber mill drives where we use a Service Factor of 4 to insure a coupling of sufficient size to provide both strength and wearing qualities to last many years for the high-speed coupling to transmit perhaps 200 hp. normal and 400 hp. maximum at 600 r.p.m. from the motor to the pinion shaft. However, another coupling is usually used between the slow-speed gearshaft to connect it to the millshaft. This usually transmits from 200 to 400 hp. and operates at only 80 or 90 r.p.m. Depending upon the number of mills taking power from this millshaft, we employ a Service Factor as low as 2 to determine the size of the low-speed coupling. This provides a coupling powerful enough for the maximum peak load or torque conditions. It also provides a coupling with wearing qualities adequate to operate at 80 r.p.m., whereas the high-speed coupling probably will be subject to less wear and less misalignment stress at each revolution, but, however, it makes perhaps six to ten revolutions to every one made by the low-speed coupling.

It will be seen, therefore, that while we list the capacities of our couplings at 100 r.p.m., the Service Factors employed take into account the usual operating speeds for the different kinds of operating machines, as well as the nature of the loading, and other operating conditions, just as important as the operating speed. These factors are the result of operating experience rather than theory alone, and it is always our endeavor to obtain full specifications of the drive for each coupling so that we can employ that experience to insure the correct size and type of coupling for each particular drive. The same is true of practically all other well-established manufactures of power transmission equipment.

Smith & Serrell, Newark, N. J. JOHN J. SERRELL.

* * * *

In answer to E. E. H.'s question, couplings, clutches and other transmission equipment are designed on a basis which allows 200 to 300 per cent greater starting torque than the required running torque, plus a factor of safety for the mechanical elements. There are two types of loads which must be considered: machine duty, or constant torque, where the torque required is constant for all speeds; and what might be termed fan duty, where the torque required varies with the speed. Machine tools, reciprocating air compressors, pumps, printing presses and so on are of the first constant-torque type, and centrifugal pumps, blowers, fans, and so on, belong to the second type.

Let us assume an example: A group of machines is driven from a lineshaft and this shaft is to be coupled at one end to another section of shaft by means of a rigid or flexible coupling or clutch. Assume that 10 hp. are required to drive the first section at a shaft speed of 100 r.p.m. A coupling or clutch rated at 10 hp. at 100 r.p.m. will transmit the required running torque and take care of the greater starting torque which is due to the static load. Let us then assume that the speed of the shaft is to be increased to 200 r.p.m. with all other conditions unchanged. In the first case a 10-hp. motor was used, but changing the speed of the driving lineshaft now requires a 20-hp. motor. The question is, what about the coupling or clutch? This will not need to be changed, because of the nature of the load, which requires constant torque, and only the speed is changed, since no greater starting or running torque is required, as shown from the following equation:

$$Horsepower = (T \times D) \div 33{,}000$$

Where T=torque in pounds, and D=distance traveled in ft. per min.

By comparing the first case, in which the shaft turns at 100 r.p.m., with the second, where it turns at 200 r.p.m., it will be observed that since the torque T remains the same for both cases and D is twice as great in the second case as in the first, the horsepower is double in the second case, as indicated by the following:

$$2 \times Hp. = (T \times 2D) \div 33{,}000$$

However, if there is no change in speed but if another section of shaft is added or a greater number of machines are driven from the same shaft, equal to an additional 10 hp. torque load, then the coupling or clutch would necessarily have to be changed as the torque T is twice as great, the speed remaining 100 r.p.m., as noted from the equation:

$$2 \times Hp. = (2T \times D) \div 33{,}000$$

It should be noted that in the above equation $2 \times Hp.$ does not mean two horsepower, but means that the horsepower is multiplied by two. Also, that for the same horsepower different size couplings or clutches must be used, depending upon the speed.

Another point to be considered in the selection of a proper coupling or clutch is the load factor, which depends upon the kind of service and nature of the load, and is considered in designing power transmitting equipment. Load factors vary from 1 on steam-turbine-driven generators to 4 on gas- or oil-engine-driven mine hoists.

For example: Suppose a coupling is required for an air compressor driven by a 40-hp., direct-connected steam engine at 200 r.p.m. The horsepower rating of the coupling is based on 100 r.p.m.; this basic rating is determined as follows: $(40 \times 100) \div 200 = 20$ hp. per 100 r.p.m. A table of load factors, such as is given by the manufacturer of couplings in his catalog, shows that for air compressors driven by a steam engine the load factor is 3. Then multiplying, $20 \times 3 = 60$, which is the horsepower rating required at the equivalent speed of 100 r.p.m. A coupling of this rating is chosen.

E. H. LAABS.
Engineering Department,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

* * * *

The following discussion will, I believe, help to answer E. E. H.'s question on the rating of power transmission equipment. The formula for horsepower transmitted is:

$$Hp. = (P \times \pi \times d \times R) \div 33{,}000,$$

where P=torque or pull; π=3.1416; d=diameter; R=revolutions per minute. In this formula the quantities, $\pi d \div 33{,}000$, are constant for a given diameter of pulley; therefore, the horsepower will vary as PR. Now, if a clutch always exerts a pull P at the pulley rim then P is a constant, too, and as far as the formula is concerned the horsepower varies directly as R (the revolutions per minute). This reasoning applies particularly to a clutch which is engaged standing still; when the shaft revolves 100, 250, or 500 revolutions it is evident that, if no slip occurs, the horsepower will be proportional and, as in the example quoted, the horsepower will be 10, 25, or 50 hp. respectively per 100, 250, or 500 revolutions.

However, in starting, the friction of rest (caused by metallic bearing contact without proper oil films or by the adhesion of belts) must be considered, together with the inertia of the complete mass which must be set in motion. These two resistances may be considerable and in some cases may demand a clutch pull much heavier than is ever called for after the shaft is up to speed.

If the same shaft, bearings, pulleys and belts are set in motion at 100 r.p.m. and then again at 250 r.p.m. and then again at 500 r.p.m., it is obvious that the same clutch pull is required at the moment of starting in all three cases. Therefore it would seem that the same clutch is all that is required. Of course, the clutch must not grab the load suddenly like a positive jaw clutch. That would mean disaster at almost any speed and certainly a worse disaster at the higher speeds. Heavy inertia loads like large fly wheels must be started and brought up to speed gradually. To do this, a friction clutch must be thrown in little by little until it is finally locked in engagement.

Starting an automobile slowly is a typical example of slow clutch engagement in order to overcome the friction of rest and the inertia of the mass. The heavier the load the slower must the automobile start to move. However, here the analogy ceases, because the automobile engine has a quite definite power pull and if the resistance met is too much the clutch must slip or the engine is stalled. In power transmission, on the other hand, there

is usually a surplus of power pull and the result is more likely to be a destructive slipping of the clutch or something must break. The automobile clutch has a fixed spring pressure against the friction members which compensates for wear, while the power transmission clutch is toggle-locked, when engaged, and there is no compensation for wear except by a new setting of the friction surfaces. The latter clutch, therefore, has a fixed pull between the friction members only when in the locked position.

The answer to this practical question lies in the ability of the power transmission clutch to slip when required and yet not have enough destructive wear on the soft friction surfaces to prevent repetitions of engagement. Hardwood or some form of firm asbestos brake lining are usually employed for the soft friction surface, although aluminum and copper are sometimes used in shafting clutches.

Test of clutches on a prony brake always indicates the development of heat in starting under load. The higher the relative speed of the two members of the clutch the greater the heat produced. If the time of engaging the clutch is prolonged, in order to start the load, and the speed is high, then inevitably the heat chars the soft friction surfaces and destroys the pulling power of the clutch. In such cases it may be found that when the clutch is fully engaged it has no longer sufficient grip to pull the load. It must then be readjusted; too frequent clutch adjustment is annoying. The obvious procedure then is to use a larger clutch with larger friction surfaces to reduce the wear and the frequency of adjustment. This can often be done with satisfactory results, but not always. It happens that as the clutch becomes larger in diameter the friction surfaces are also farther out from the shaft and their relative speed is actually increased; the effect, therefore, of larger clutches for higher speeds is more or less neutralized.

The judgment of experience seems to be the only guide in proportioning the clutch size to the speed.

Chief Engineer, HARRY J. SMITH.
The Hill Clutch Machine & Foundry Co.,
Cleveland, Ohio.

* * * *

Does Change in Transformer Connections Affect Rated Capacity?—I have three 100-kva., single-phase, 2,200-110-volt transformers, which I intend to connect in a bank to deliver three-phase power at 110 volts. If a delta-delta connection is used to connect the bank, what power capacity can I get from the transformers? Will I get the same power capacity from a star-star connection? I shall appreciate any information that readers can give me on this question.
Telluride, Colo. T. H. C.

Answering the question by T. H. C., it may be said that he has no choice of connections to use other than that which will give rated voltage on each transformer.

As the rated voltage of the transformers is given as 2,200/110 a delta-delta connection should be used if the primary voltage is 2,200 volts; this will apply 2,200 volts to each transformer. If the primary voltage is 3,800 volts a star-delta connection should be used which will give 3,800÷1.73 or approximately 2,200 volts applied to each transformer. It may be mentioned that any increase or decrease in primary voltage will directly affect the secondary voltage, in this case by the ratio of 20 to 1.

Denver, Colo. JOHN E. HOLTMAN.

* * * *

In his question, T. H. C. did not mention the voltage to which he intends to connect the transformer bank. Assuming that the voltage of the service to which the transformers are to be connected is 2,200 volts, the capacity of the bank connected delta-delta equals phase voltage×phase current×3. With this connection the phase voltage and line voltage are equal and the full-load phase current of a 100-kva. transformer will be 45.5 amp. Hence, the output of the transformer bank will be 2,200×45.5×3=300 kva.

With the star-star connection, the phase voltage or voltage impressed across the transformer primaries is line voltage÷√3, while the phase current equals the line current equals 45.5 amp. Hence, the full-load output of the transformers with a star-star connection on a 2,200-volt supply will be (2,200÷√3)×45.5×3=173 kva.

I hope that this will give T. H. C. all the information necessary.

Chicago, Ill. A. NOEPPEL.

* * * *

In answer to T. H. C., changes in connections of the three 100-kva., single-phase, 2,200/110-volt transformers, would not alter the capacity of the transformers as long as they are operated at the voltage for which they are designed. The 220-volt primary coils of a 100-kva. transformer will carry 45.5 amp. at full load. With the three transformers connected delta-delta on a 2,200-volt system, the primary coils of each transformer will be carrying 45.5 amp., the line current will be 78 amp. or 1.73 times the current in the primary coils, and the output of the bank of three transformers will be 300 kva. If these transformers were connected star-star to a 2,200-volt system, the voltage across the primary side of each transformer would be 2,200÷1.73 or 1,271 volts. With each transformer carrying full-load current of 45.5 amp. the output of each transformer would be 1,271×45.5 =58 kva., and the capacity of the bank would be only 3×58=174 kva.

The usual conditions under which 2,200/110-volt transformers are connected in star, would be with a line voltage of 3,800 volts and the transformers connected star-delta. In this case each transformer would have 2,200 volts across its primary and with 45.5 amp. primary current would be carrying a load of 2.200×45.5=100 kva. The output of the bank would be 3×100= 300 kva., and with the secondary side connected in delta, the secondary voltage would be 110 volts, since the transformer voltage ratio is 2,200/110 volts.

The use of 2,200/110-volt transformers in this way has usually come about through an increase in line voltage from 2,200 to 3,800 volts. This gives the utility company increased line capacity at small expense, since the same transformers can be used. The generators may be so arranged that the ends of each phase winding are brought out giving six terminals; hence the windings may be connected in either delta or star. If in delta, the terminal voltage will be 2,200 volts; if in star, 3,800 volts. If the utility company's lines are operating at 2,200 volts, three-phase, three-wire, and it is desired to increase the line voltage to 3,800 volts, the generator windings are reconnected in star and usually the common point of the star is grounded and is also connected to a fourth wire, giving a three-phase, four-wire system. The voltage between the first three wires is then 3,800 volts and the voltage between any one of these and the fourth wire is 2,200 volts. The primary sides of all of the transformer banks are then reconnected in star and will operate with a line voltage of 3,800 volts and will have 2,200 volts impressed across the primary of each transformer. With the secondary connected in delta, 110 secondary volts will be obtained. The fourth wire with any one of the others provides a 2,200-volt primary supply for the single-phase lighting transformers, which can be balanced across the three phases.

If T. H. C.'s primary voltage is 2,200 volts, his transformers should be connected, delta-delta to give 300 kva. with a secondary voltage of 110 volts. The transformers should be connected star-delta if his line voltage is 3,800 volts and should not be connected star-star in any case if it is desired to operate them at their rated capacity of 300 kva., with a secondary voltage of 110 volts. If the star-star connection were used under these conditions, the secondary voltage would be 110×1.73 =190 volts, which is a higher secondary voltage than would be desired for a 110-volt secondary circuit.

East Cleveland, Ohio. L. J. JOHNSON.

* * * *

Method of Cleaning Motor Winding—What is the best method of cleaning motors that are oil-soaked and dirty? Can they be washed in gasoline and baked out in a bake oven to any advantage? What is the best method of handling the gasoline? Should the armatures be dipped in a trough containing gasoline, or should they be wiped with a gasoline-soaked rag? I would greatly appreciate hearing of any other methods used by readers for cleaning oil-soaked windings, as well as the results obtained by using gasoline for cleaning.
Chicago, Ill. R. W. A.

With reference to R. W. A.'s question, machines that are dirty and dusty, but not oily, may be readily cleaned with dry compressed air. In using compressed air, be careful not to direct the air stream into the oil wells or you are likely to have oil sprayed all over the windings.

If the machine is oily and dusty, it should be disassembled, the windings scraped with tools which have no cutting edges, and then washed with gasoline or naphtha, using stiff bristle brushes. If you have a nozzle arranged for air and naphtha, similar to those used for spraying paint, you can use it to advantage. In all cases when using compressed air, direct the stream so that material will not be blown into

any crevices in and around the winding.

Remember that this work should be done in a well-ventilated room. Keep away from flames or fire. Do not apply any dielectric tests until you are sure that the gasoline has entirely evaporated. C. N. SHAFER.

Supt. Service Division,
The Lincoln Electric Co.,
Cleveland, Ohio.

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With reference to R. W. A.'s question, a method that I have found very satisfactory is to squirt a stream of gasoline from a blow torch into the windings. When applied in this way the gasoline penetrates the small spaces that you cannot get into with a rag. At the same time the windings are not soaked, as is the case when they are dipped in gasoline. When cleaned in this way, I think that a motor will dry out enough in a few hours to be put back into service without baking.

Louisville, Ky. WILLIAM F. GARCIN.

* * * *

Answering R. W. A.'s question regarding the care of motors, the prevailing practice at U. S. Nitrate Plant No. 2, where there are some 600 motors, ranging from 400 hp. down, to be kept in first-class condition, is to remove the rotor and then clean off all rust from metal parts. We use a gasoline spray to clean all parts thoroughly, and when they are dry we apply a good grade of air-drying insulating varnish. This varnish is applied with the same spray as is used for the gasoline, and by using about 60 lb. per sq. in. air pressure, all surfaces are reached.

In cases where motors are affected by dampness it is well to apply one coat of Ozite, a pothead compound made by Standard Underground Cable Co., Pittsburgh, Pa. This is prepared by first heating to a liquid state and adding sufficient gasoline to make it easily applied with brush. The gasoline will evaporate, leaving a good coating of damp-proof insulation. It is best to apply this when warm.

The spray used is a home-made affair, in which the materials to be applied are syphoned into the head and thereby broken up by the air. The density of the spray is controlled by a valve in the suction line.

Plant Engineer, J. F. GORDON.
U. S. Nitrate Plant No. 2,
Muscle Shoals, Ala.

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Replying to R. W. A., regarding method of cleaning motor windings, I have got excellent results by using gasoline and compressed air, at about 60 lb. pressure. For this purpose a small tank will be best, since in some cases the motors are in inaccessible places or on the side of a wall, and an outfit that can be carried easily is necessary. An old Presto-Lite tank can be used, if one is available. Fit the tank with a small pipe extending from the outlet to within about an inch of the bottom, on the inside. The outer end of this pipe should be provided with a valve and a hose connection.

Another piece of pipe should be screwed into the top of the tank and likewise provided with an air valve and hose connection for connecting to the air line.

When the tank is ready fill it about two-thirds full of gasoline and connect the short pipe (the one that just goes through the top of the tank) to an air line of about 60 lb. pressure per sq. in. When the air is turned on it will cause a fine spray of gasoline to be forced up through the long pipe. By means of a short piece of hose this spray can be directed to any part of the winding, and the dirt and oil will soon be loosened and blown out without harm to the winding, as the gasoline will soon evaporate. No oven will be needed to dry the motor.

Service Dept., M. V. MILLER.
Westinghouse Elec. & Mfg. Co.,
Indianapolis, Ind.

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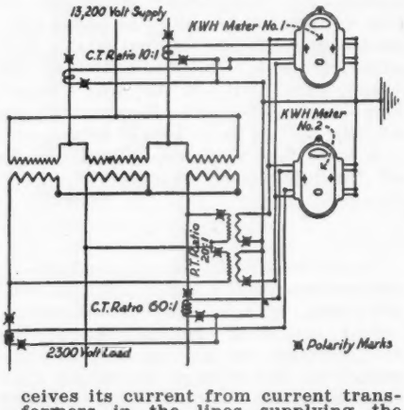
Will These Watt-hour Meters Read Alike?—The diagram shows a proposed method of connecting watt-hour meters on the primary and secondary sides of a bank of transformers connected delta-star. As shown, the meter measuring the high-tension power receives its current from current transformers in the lines supplying the delta-connected primary, while the potential supplied is the low-tension line voltage. The low-tension watt-hour meter is connected in the usual manner. I should like to know if this connection for No. 1 meter will work satisfactorily. Also, if we disregard the copper and iron losses in the transformers will there be any difference in the records of the two meters at unity power factor, and at 85 per cent, 70 per cent and 45 per cent lagging power factor, assuming that the load is always balanced?



Longview, Wash. J. C. R. C.

Referring to J. C. R. C.'s question in a recent issue, I would not recommend the watt-hour meter connections shown in the diagram. The principal reason for installing watt-hour meters in both the primary and secondary sides of a transformer bank would be to determine the power loss in the transformers themselves. The greater portion of this loss is due to voltage drop in the windings caused by resistance, hysteresis, and eddy currents. In order to have these losses included in the reading of the supply meter it would be necessary to have the potential coils of this meter energized at the primary side.

The hysteresis loss and the reactance of the coils produce a reactance component in the impedance of the windings, which results in the voltage induced in the secondary being slightly out of phase with that in the primary. This phase angle is much greater in power transformers than in instrument transformers. It also varies with the power factor of the load, as do the copper and leakage losses. Therefore, there would be a variation in the readings of the two meters with every change in power factor, in addition to the error from the first-mentioned cause.

However, the two meters could not be made to check even if properly connected, as meter No. 1 includes the transformer losses, which are variable. The connections illustrated would give correct rotation, providing the transformers were additive polarity. Otherwise the potential or current connections at meter No. 1 should be reversed.

Chief Electrician, LYLE HENDRICKS.
Pickands, Mather & Co.,
Hibbing, Minn.

* * * *

Referring to the question by J. C. R. C. in a recent issue, this connection will not be satisfactory for No. 1 meter.

Taking the diagram just as it is now, the current transformer on the left leg of the high-tension side should be changed to the center leg, thus placing current and potential of the same phase on the lower element of No. 1 meter. Now, assuming that the meters are properly calibrated, the two meters will read exactly alike which, of course, is incorrect, as both meters will be registering the output on account of the potential transformers being on the low tension side.

The best thing to do in this case is to use a separate pair of potential transformers on the high-tension side; then the input will be metered on No. 1, and the output on No. 2.

Under these conditions, the difference in the readings will be the transformer losses only, as the varying power factor, being purely a load condition, will affect both meters alike.

Detroit, Mich. J. J. CONWAY.

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Answering the question by J. C. R. C. in a recent issue, the metering arrangement which he shows is incorrect. It is evidently desired to eliminate the use of 120 to 1 potential transformers for meter No. 1. I believe it will follow from the discussion below that an installation of enough importance to require a meter on the high side of a transformer bank, such as is described, is also of enough importance to justify the correct potential transformers on the high side, for accuracy.

A short consideration of the phase relations of the potential which should be applied to the potential coils of No. 1 meter, and the phase relation of that actually applied, will show why the installation is incorrect. Calling the transformers from left to right *a*, *b*, and *c*, the potential coil in the upper element of No. 1 meter should be excited by a voltage in phase with the voltage of the high side of transformer *c*. It is actually excited by a voltage which is taken from the potential transformer across the leads of transformers *b* and *c*. If this potential were in phase with that of transformer *c* or in phase opposition to it, connections could be made correct, disregarding the errors in the power transformers. However, the voltage applied is leading the volt-

age which should be applied by 30 deg. In addition, the diagram shows the primary line voltage to be 13,200 volts and the secondary line voltage to be 2,300 volts, which indicates that the transformers are not of straight ratio. If they were the secondary line voltage would be 2,200 volts. Therefore, it would be necessary to include this odd ratio in the calculations to find a new constant for the meter.

However, consider that all constants are correct and that it is desired to find a new constant to correct the condition of the meter voltages being 30 deg. out of phase. The effect of the actual voltage across the potential coil leading the correct voltage by 30 deg. would be that the meter would measure power the same as though the current were lagging 30 deg. more than it does in fact. For example, if the meter were metering power whose current was lagging 10 deg. with a power factor of .984, the meter would measure the power as though the current were lagging 40 deg. with a power factor of .766. Assuming different angles of lag and continuing the calculations of finding power factors, it will be seen that there would never be a definite ratio between the correct power factor and the power factor for which the meter is corrected. Therefore, no constant could be applied to make the readings correct.

The obvious thing to do would be to install a separate set of potential transformers on the high side of the bank. It would also be possible, although not good practice, to connect another set of potential transformers on the low side, using transformers *a* and *c* and connecting each potential transformer from the line to the star point. However, since it is evidently desired to measure transformer losses in kilowatt-hours the percentage of error in metering, caused by the fact that power transformers do not have as correct a ratio of transformation for all loads as do potential transformers, might be greater than the percentage of transformer loss.

Answering the latter part of the question, if the meters were correctly connected and calibrated there would be no error regardless of balance or value of power factor.

Toronto, Ohio. HERBERT KING.

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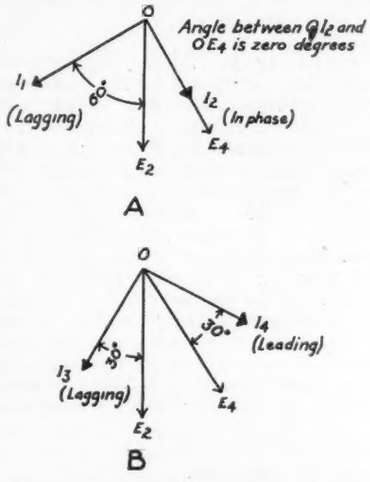
Answering J. C. R. C. in a recent issue, the two meters connected as shown will not register the same.

Meter No. 2 will register correctly under all conditions of power factor. Meter No. 1 will vary in its registration depending upon the power factor, since it is incorrectly arranged. The reason for its incorrect registration is the angular relation of the current and voltage introduced through the star-delta connection.

At 100 per cent power factor, meter No. 1 has one element in which the current is in phase with its voltage, while in the other element the current lags 60 deg. behind its voltage. In the case of meter No. 2, the current in one element leads its voltage by 30 deg., and the other lags behind 30 deg.

The relations of current to voltage in meter No. 1 are correct for the registration of the total energy used, and are shown vectorially for 100 per cent power factor in diagrams *A* and *B*. In diagram *A*, OI_1 and OI_2 represent currents in the 13,200-volt line; OE_2 and OE_4 represent the voltages between the 2,300-volt lines.



Vectorial relations of current and voltage at 100 per cent power factor in meter No. 1, shown at A, and in meter No. 2, shown at B.

The approximate relations of the registration of the two meters for the power factors listed are as follows:

POWER FACTOR	METER No. 1	METER No. 2	RATIO OF 1÷2
100	1.5	1.732	0.886
85	0.8185	1.472	0.556
70	0.4308	1.2084	0.356
45	—0.0987	0.7792	—0.127

This tabulation assumes of course that the load is always balanced. It should be noted that at 45 per cent power factor, meter No. 1 will run backward. Referring to the diagram, only the actual vectors which are involved, have been given. This was done to avoid confusion and to aid in making the relations clearly and easily understood.

As previously stated, the relations shown in the diagram are for 100 per cent power factor. For all lagging power factors, the current vectors will swing in a clockwise direction. For instance, at 45 per cent power factor, the angle between E_2 and I_1 will become 123.3 deg., and 63.3 deg. between E_4 and I_2.

It is also assumed that both meters are arranged for direct reading without the use of a constant, or in other words, have the correct gear ratio to suit the current and voltage transformer ratios.

This method of metering has been used but usually only with delta-delta connected banks, making allowance in meter No. 1 for the transformer losses by adjustment or other compensation. The correct solution in this particular case would be to install 13,200-volt meter voltage transformers.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

Use of Armored, Lead-Sheath Conductor Underground—Will some of the readers of INDUSTRIAL ENGINEER please give me their experience with the use of 2,500-volt, lead-encased, steel-wound wire such as is put out by some of the large manufacturers and intended to be used underground, and not protected by conduit?

San Diego, Calif. W. P. B.

In answer to W. P. B.'s request for information on the use of armored, lead-sheath conductor underground, I would like to state that we have roughly 10,000 ft. of this kind of cable in use at the present time.

It is used for power and lighting mains and is buried in the ground, with no protection whatever. It has been in use for the past ten years and we have had no trouble with it, although the lines have been moved in some cases two or three feet when making additions or alterations to buildings. So far as we can see, these lines are today in as good condition as when installed. HAROLD W. STEELE.
Ass't. Electrician,
Naumkeag Steam Cotton Co.,
Salem, Mass.

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Replying to W. P. B., this type of conductor has found its greatest use in street lighting service where the lighting standards are located in the grassy portion of the parking between the curb and the sidewalk. It is also in extensive use in city parks where it is buried directly under the sodding, from 18 in. to 30 in. deep. Further, it has been widely used in England, and to a limited extent in this country, for general distribution work. For general service, however, its use is limited to districts where it is not expected that the load will increase materially. A large increase in the load makes it necessary either to lay new cable or dig up and replace the old one.

A standard line of junction boxes and fittings is available for this type of cable, and while its use in this country dates back not much beyond ten years, it is increasing in popularity. No particularly severe troubles have been encountered with it in service and when the lead sheath is protected with a jute covering, then with a double steel tape and another covering of jute over the tape, the life of the cable would appear to be indefinite. I know of some installations under railroad tracks that have been in service for over nine years, without a single case of trouble. C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson and Porter,
Springdale, Pa.

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I would like to give W. P. B. an idea of our experiences with armored steel cable, lead-covered and jute-wrapped outside the steel bands. The company with which I am now associated uses as much or more steel-armored cable than any other company in the South. We operate about 12 slopes and several drifts. All mines are supplied with alternating current. The tipple equipment fans and pumps are driven by 2,300- or 550-volt a.c. motors. We have installed both armored and weatherproof cable; the latter is used only on the 550-volt circuits.

Potheads are only used on the powerhouse cables and on the 13,000-volt cir-

cuit. Most of the cables are just cut the desired length, the armor stripped back, the ground insulation removed and the rope core cut out at the crotch of the three conductors. The lead sheath is rolled back, so as not to chafe conductor insulation. Then several layers of varnished cambric tape are woven in between and around the three conductors to form a sort of insulating cushion, and to keep the wires spread apart. This tape is covered with several layers of P. & B. waterproof tape, which is warmed with a blow torch when applied, and this is topped with a heavy coat of insulating paint. A cable so treated is waterproof for a reasonable length of time, but as the varnish ages and dries out, the moisture penetrates the cracks and will cause a breakdown to ground. These crotches or splices should be painted with a good insulating varnish ever so often, according to conditions under which they operate.

Another method that I have used for crotching cables is to use linen tape and dip it in boiling or hot paraffin wax, dipping every time a layer of tape is applied, and dipping the finished crotch several times to be sure of a heavy outside coating. The above method is simple and requires no great mechanical skill; almost any mechanic around the mines can make a simple and reliable cable repair with a little practice. But cables so treated must be inspected at regular intervals, or they will be a constant source of trouble; at each inspection we generally paint the joint or crotch.

If cables are put up with potheads and splices are sleeved over with a lead sleeve, they are subject to very little trouble, whether inside or outside the mines, but as cable splicing is, or has become, a trade in itself, there are not so many electricians who are able to do good cable splicing. Although almost any telephone man can give one pointers about cable splicing, and with a little practice and judgment a mechanic ought to be able to make a decent wiped joint.

I know of one large mining company which has several miles of 6,600-volt, three-conductor, steel-armored cable and some without lead or armor, but it is all laid in fiber duct on the trolley wire side of the mine track. They made their joints in junction boxes and the joints were coated with hot paraffin.

In one instance I dipped water off a joint in this cable with an iron bucket; the juice was on and we were afraid the joint might blow if the water were not removed. However, this was not so much of a gamble as one might think, because these joints are waterproof if correctly made and maintained.

Steel-armored cables should not be suspended in bore holes or shafts because their weight soon exceeds their safe strength and as the wires are woven around the core, they tend to flatten out; this crushes the intervening insulation, causing a breakdown. Cables can be supported by suitable clamps, on a messenger; one strand of tiller rope can also be used to tie it to messenger cable.

There is one objection to cables and it is this: when one cable on a system becomes grounded and does not blow a fuse or knock the breaker, all of the other weak cables or joints are subjected to a strain until the defective cable or part is removed. When one cable breaks down several more are likely to follow suit, if many are in operation.

GRADY H. EMERSON.
Ass't. Chief Electrician,
Alabama Fuel & Iron Co.,
Acmar, Ala.

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Answering W. P. B., we have one 2,500-volt, three-conductor, lead-covered, wire-armored cable about 3,000 ft. long, which was installed in 1910. This cable has never given any trouble and megger insulation tests show it to be still in first-class condition. The cable was laid in a trench about 2 ft. deep and, as there was likely to be some later digging in the vicinity of the trench route, rough planking was placed over the cable before backfilling with the excavated earth. It was not expected that the planking would serve as a protection to the cable, but it was used simply to indicate to workmen uncovering it that they were close to the cable and should, therefore, use caution in further digging in order not to injure the cable.

This particular cable has 30 per cent Para rubber insulation, but manufacturers will make cable to any specifications required. The standard specifications of the Joint Rubber Insulation Committee may well serve as a guide in buying this class of cable, which has been so standardized as to be quite reliable. With proper care in manufacture and installation there is no reason why such a cable should not last as long as a plain, lead covered one in ducts.

Regarding the installation of this kind of cable, the methods to be followed will vary with the length to be installed, size of the cable (since this affects the unit weight), and with the character of the ground. For short lengths and small-size cable, ordinary methods of handling the cable may be used.

For longer lengths and larger sizes of cable which is to be run in open ground which may be traversed by a truck, the easiest method is to mount the reel on a truck and pay off the cable by hand into the trench as the truck proceeds along the trench route. If steep, hilly country or swampy ground is to be covered, over which a truck could not travel, the best way is to set the reel up at one end of the trench and place pieces of timber (preferably rounded pieces of sapling) across the trench at intervals of 20 ft. or so. If the trench route is passable for a team it is then fairly easy to have the team walk along the trench route, pulling the cable end along as they go and letting it ride on the timber cross-pieces. A good team can pull out 500 ft. of average-sized cable in this way. If the trench route is not passable to team or truck, a winch may be set up at intervals along the route and a lead line from this used to pull the cable into place.

It goes without saying that kinks in the cable should not be permitted under any circumstances and this, therefore, implies some previous experience and considerable care in the installation. Splicing should be done only by men experienced in this class of work, as cable failures usually occur at joints. An iron pipe sleeve long enough to reach from armor to armor should be threaded on the cable before splicing and then secured over the splice after it is made. Potheads of proven worth should be used at all cable ends. The pulling line used in laying the cable should be attached to the armor wires and not to the cable itself, which should be sealed to prevent the entrance of moisture.

Fort Worden, Wash. E. I. PEASE.

* * * *

Method of Removing Cores from Fan Motors—Will some reader tell me the best method and equipment to use for removing the cores from 10-in., 12-in., and 16-in. Westinghouse fan motors? I find it necessary to remove these cores from the drawn steel housing that encloses the motor so as to be able to make repairs on the connecting wires, which usually burn off very close to the housing. This connection cannot be made on the outside. These field cores fit so closely that it is almost impossible to remove them without injury to the windings with all the methods that I have tried so far.

Madisonville, Ky. E. F. L.

With reference to E. F. L.'s question on removing the cores from Westinghouse metal-frame fans, make a cylinder one and one-half times as long as the core is wide, with the inside diameter slightly larger than the outside diameter of the core. The outside diameter of the cylinder is not important, so long as the wall is as thick as the frame of the fan. Strip the fan down to the core and frame and slip the cylinder over the edge of the core, where the end bell comes off. Grasp the cylinder and core in both hands and hammer down on a solid block; the core will drop in the cylinder after a few blows.

The core may be put back into the frame by clamping the frame in a large vise and using a smaller cylinder held against the core for driving it into place.

Augusta, Ga. O. B. EVE.

* * * *

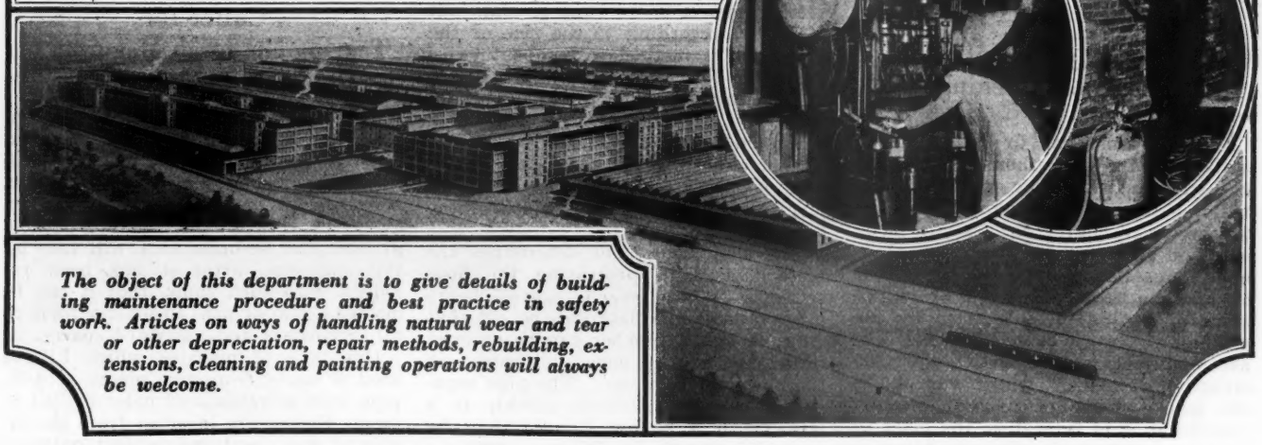
Referring to E. F. L.'s question, the best method I have found for removing Westinghouse stators from the frame is, first, to remove the casing from the oscillating housing or the swivel, in the case of a straight fan, which is generally held on by means of four screws.

Then take off the fan end bonnet or end bell and with the motor held in a vise, saw through the outside housing between the screw holes in the bottom where the oscillating case or swivel was taken off. This will relieve the pressure on the laminations and the core can be removed quite easily. This saw cut will not show when the fan is reassembled and will not throw the bearings out of line or in any way affect the running of the motor.

There is a very good article by Carl G. Howard in the August issue of INDUSTRIAL ENGINEER, page 400, on removing cores. The method there described will work in most cases, but where the cores are as tight as in Westinghouse fans I have found it to be quite unsatisfactory.

Minneapolis, Minn. A. L. WALLOF.

Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Putting an Acid Fume Discharge System Outside the Building

SOME time ago, the pickling department of our plant installed an exhaust system for removing the fumes from the pickling vats. These vats are 23 ft. long, 4 ft. wide and 2 ft. deep and are built in pairs, a pickling vat and a washing vat constituting a pair. Two pair of these vats, besides several smaller vats, are installed in this department which is in a room approximately 50 ft. long, 30 ft deep and 14 ft. high where it joins the shop proper, with a 2-ft. drop in a sloping roof.

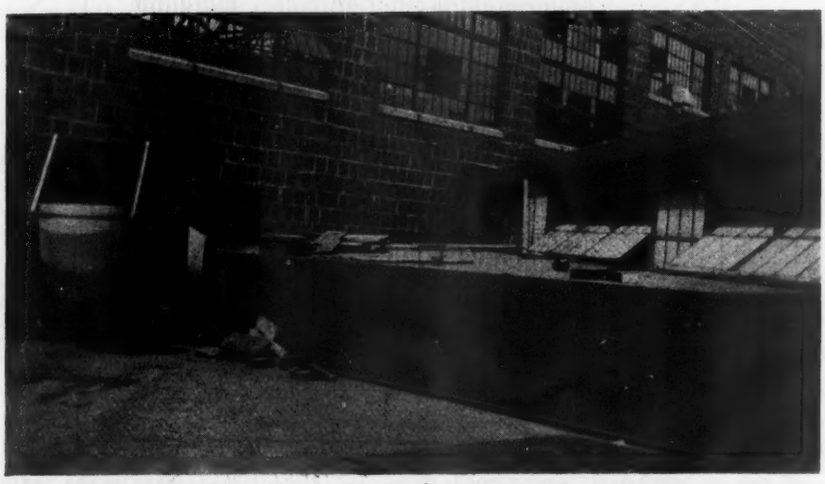
The product is handled in and out of the vats by an overhead monorail system and the low headroom made it impossible to use a suction duct between a pickling and a washing vat. Also, this system would have left the several smaller vats in the room uncared for.

After a thorough study of this problem, we decided that a complete change of air was necessary in this room every 2 min. to maintain desirable working conditions. For this purpose an American No. 4 Sirocco fan with a capacity of 12,000 c.f.m. discharge was used; this is driven at 829 r.p.m. by a 15-hp. Westinghouse motor.

A hole 2 ft. wide and 35 ft. long was cut in the high side of the roof, which was suitably reinforced, and a triangular hood built over the opening on the outside, as shown in the accompanying illustration. This hood extended horizontally and was connected to the blower. All surfaces exposed to the fumes were given two coats of acid-proof paint. A penthouse was built over the blower and motor to protect them from the weather.

The low cost of installation, and the efficient results of this equipment make it highly satisfactory. However, we would have considered an addition to this system had our appropriation been sufficient to permit it. This would have consisted in running a ¾-in. air line around the large vats, and, I think, it would have been an improvement. This pipe was to be perforated with several ⅛-in. holes drilled at an angle of 45 deg. to the horizontal and connected to our high-pressure air line. When operating the vats, the plan was to crack a valve and so admit sufficient air through the perforated holes to break up the fumes and thus facilitate the action of the fan. This can still be added if the present exhaust system is not sufficient to maintain good working condition in the plant when it is closed up during the winter.

Chester, Pa. H. E. PILKINGTON.



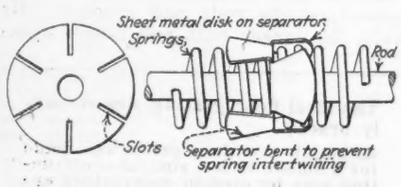
Because there was no room inside, this duct and blower were placed outside the building.

The overhead monorail system for handling material in and out of the pickling vats, prevented putting an exhaust duct over the vats. This outside exhaust duct, with sufficient capacity to change the air in the room every 2 min., provides the necessary ventilation.

How to Use Cut Disk as Separator Between Two Springs

IT IS not practicable to place two springs end to end without some form of separating disk between them, especially where the springs are wound to the same right or left pitch, as they will intertwine and reduce the effective length of spring.

On one job, in which a number of springs were used with a push rod as counterbalances for sashes, the problem of providing separators between the ends of the springs, was met with simple sheet iron disks made as shown in the attached sketch. These washer-shaped disks are about ½-in. to ¾-in. larger in diameter than the coil of the spring and have a hole punched in the center, to fit over the pull rods. The



Sheet-iron disks are slit as shown and tabs bent alternately up and down over the ends of the springs.

disks were slotted about half-way radially and the tabs thus formed were alternately bent up and down to engage the spring ends as shown. These disks were easy to make and less expensive than punchings, cup-shaped drawings, or castings.

Washington, D. C. G. A. LUERS.

Construction of Metal Grating for Floor Openings

THE engineer or the master mechanic who has to build and install floors for smoke houses or for dry kilns, gratings to cover openings about buildings or coal holes along sidewalks, hatches over shafts, fire escape members and other similar places may, perhaps, appreciate having the experience of another from which to draw, instead of having to start from the beginning and work along unaided. The accompanying sketch shows the construction of a floor, which was put in the smoke house of a local packing plant, but it is typical of the class of gratings mentioned. This building is 10 ft. by 9 ft. 6 in. inside and had been used for other purposes, but remodeled for use in smoking hams and bacon. It is two stories high and the same types of floor and floor setting are used on both levels.

It is not safe to figure such floors on a passing or moving load basis only; there is always the possibility of storage upon the floors, even though the "work" may be intended to be hung from hooks or tracks. Also, a group of people may stand upon the floor, boxes may be dropped, or any of a dozen things happen that impose stresses far greater than the anticipated load of one person. To guard against such contingencies, we put four 4-in., 7½-lb. I-beams under each grille floor and set the ends 6 in. into the brick work, cemented them up when leveled and waited for them to set before laying the floor. The beams run at right angles to the slats of the grille, which are crosswise as one enters the door of this room.

For ease in handling and making, the floor was put up in three sections, each of which consists of 19 slats with the accompanying tie rods and spacers. The size of the sections of such grilles is regulated by the floor area, the support beneath, and the strength of the grille itself. In this particular case, light tie rods (⅜ in.) were used because the I-beams on 2-ft. 10-in. centers back up the slats and carry all the load at right angles to them. In other cases, the ends of the slats might rest upon a ledge or wall without other support. In such cases dependence for stiffness and against weaving must be placed on the rods and spacers; this calls for larger rods and larger spacers or separators. A ⅜-in. rod is so weakened by cutting a standard thread on it that life and limb should not be trusted to it, except possibly for short spans.

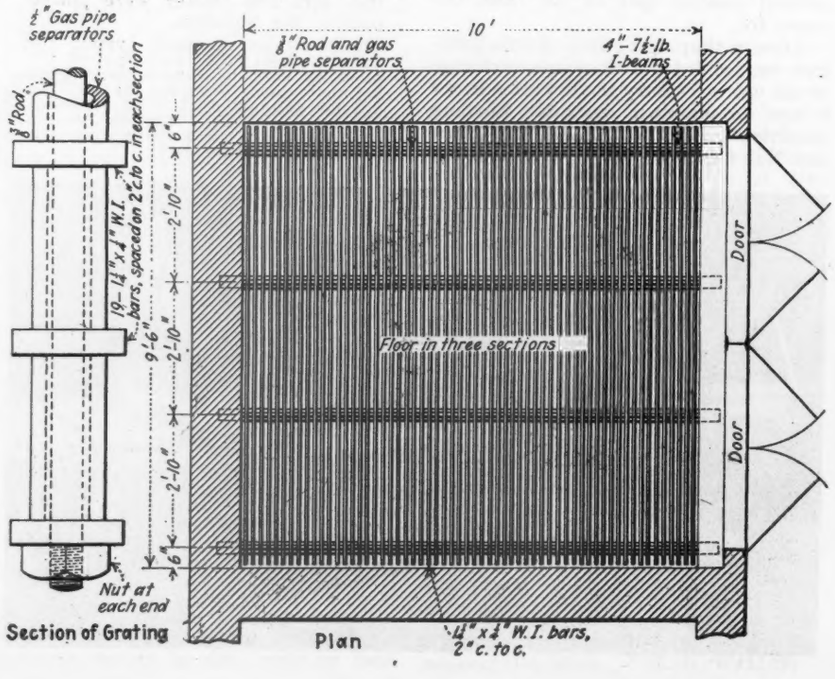
Grille floors are sometimes constructed by bending long flats in parallel runs spaced about 2 in. apart, thus getting two or more runs or slats out of a bar, according to the size of the space. This method costs about twice as much for labor and is no better than using separate pieces. Usually ¼-in. or ⅜-in. flats, 1¼ in. wide as a minimum, are employed for grilles; the former is desirable in most cases. The pipe separators should be nearly as large in diameter as the width of the flats.

The shop equipment determines the method used in processing the floor sections. Where lever or power shears are available the flats will be cut that way; if not, a number can be gripped in a vise at one time and sawed in the power or cold saw. The pipe separators can be cut more quickly in a lathe with a hollow spindle than by any other method. When a lathe is not available they can be sawed off. Their length need not be exact, but they should be uniform in order to produce a well appearing floor.

The slats may be turned out quickly. After cutting off, they have to be drilled for two or more (in this case four) tie rods. To do this, one slat is laid off and drilled; this is then clamped on top of a stack of others as a templet. When a number of floors are being made at one time, some of the drill-vise-jig devices might be used to advantage. Shops with facilities for punching would probably punch the holes instead of drilling them. Assembling is a job that even a boy can't do incorrectly.

Such gratings or grille floors could be more extensively used than they are. Many openings now closed with boards and trap doors would be better, safer and more fireproof with grille covers. Shops without the facilities for making grilles, or those which do not care to enter into this type of work, will find several grilles on the market which may be used.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.



The steel floor grating was strongly braced.

Although this floor grille was made for a smoke house, similar construction may be used in many other applications. Particular care must be taken to see that the grille is properly supported and has no opportunity to "weave" when men are working on it.

Cutter for Tearing Up Scrap Magnesia to Be Used Again

MOST maintenance men know that if old magnesia which has been removed from pipe lines can be utilized, it has considerable salvage value. However, in many cases it is thrown away. A very simple and inexpensive grinder can be made that will tear up this material, after it has been removed, into such shape that it can be molded again or used in plaster form to fill in corners and awkward spaces.

One type of machine which I have used is made from two pieces of 4-in. pipe with a number of holes drilled in them. Spikes are inserted from the inside of the pipes and project outward through these holes; the spikes are held in position by hollow, hardwood cores passing through the pipes. Short steel shafts fitted with pinions are fastened to the ends of the cores in the pipes, and the latter are then mounted in a suitable frame. The shafts are spaced in the frame so that the ends of the spikes are about ½ in. apart. A crank handle with a gear, which is placed so that it meshes with the pinions, drives the shafts through the pinions.

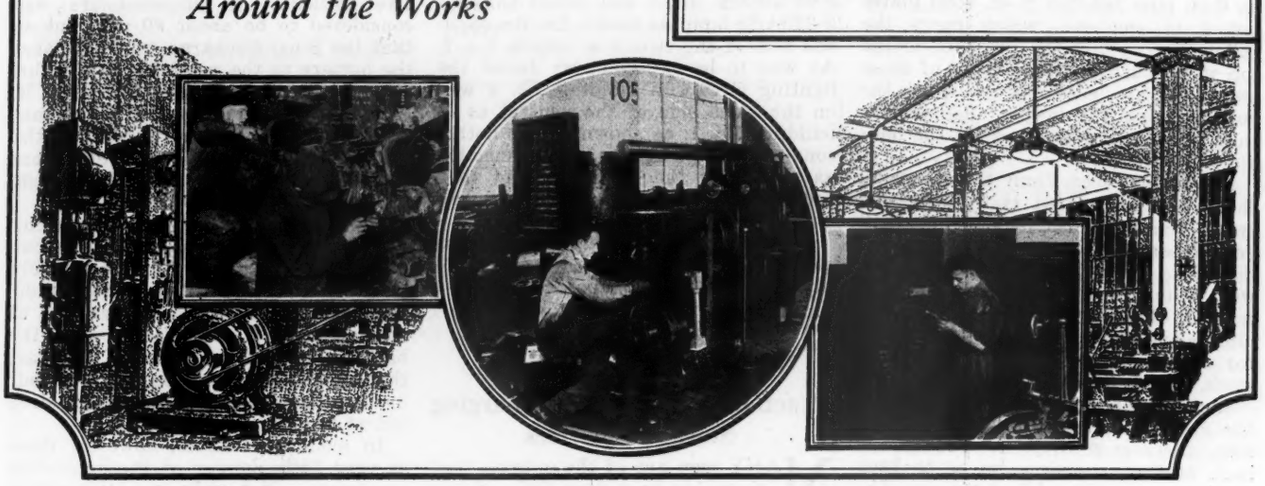
This cutter or grinder is placed in a trough-shaped frame and the scrap magnesia is fed into it. It is surprising how effectively this contrivance will rip up such material. An ingenious operating man could probably improve on such a device if sufficient quantities of material are available to make it worth while.

MAURICE C. COCKSHOTT.
Engineering Department,
Emsco Steel Products,
Los Angeles, Calif.

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Better Product with Less Hazard by Using Electric Heat

IN THE manufacture of kegs, the finished staves are placed in a barrel machine which bends the staves into the form of the finished keg. A heavy steel ring is then placed at each end of the staves. It is necessary to heat the barrel thoroughly before these steel rings are removed and the hoops applied; otherwise, either the hoops would break or the staves would crack.

The heating elements of the heaters consist of standard Westinghouse space heaters, assembled on a circular frame. There are two series of heaters, each series consists of six heaters, and stands opposite a machine which assembles the staves in the steel rings.

The operator takes a barrel from the machine, raises the cover by means of a foot lever and sets the keg over the heater with the space heaters inside. The foot lever is then released and the cover drops. In a minute or two the keg is taken from the heater, ready for the hoops.

Before installing the electric outfit, open flame heaters were used, in which waste-wood was burned. Six of these heaters were set together in a large brick structure resembling an open fireplace. It was not only hot and disagreeable for the workmen, but there was considerable fire risk. After a disastrous fire in 1921, we decided to do away with unnecessary fire hazards, and the electric heaters were installed.

Since the installation of the electric heaters, there has been less breakage in manufacture, due to the fact that with electric heat the barrel appears to be heated uniformly throughout with rapid penetration of heat to the exterior of the barrels. And no barrels are lost by overheating nor do they catch fire. The cost of the installation has more than paid for itself by giving a better product, reducing fire risks and improving working conditions.

Spalding & Frost Co., Fremont, N. H. S. A. FROST.

Arrangement of electric space heaters which replaced a wood burning stove in a cooperage plant with considerable economy and other advantages.

Comment on "Maintenance of Large Motors in Steel Mills"

IN THE article by O. Needham on page 423 of the September issue, I noticed that the formula given for measuring insulation resistance with a voltmeter is as follows:

$$R=[(V-v)\times r]\div V$$

where R=the insulation resistance
r=the resistance of the voltmeter
V=the line voltage
v= the voltmeter reading

In the American Electricians' Handbook this formula is given in the following manner:

$$R=r\left(\frac{V}{v}-1\right)$$

As these formulas do not seem to be equivalent, I would like to know why there is such a great difference between them.

Jersey City, N. J. W. J. STERNAD.

* * *

There is a typographical error in the formula as printed on page 423. Correctly stated the formula should read:

$$R=[(V-v)\times r]\div v$$

This formula can be transposed to the same form as given in the American Electricians' Handbook as can be seen from the following equations:

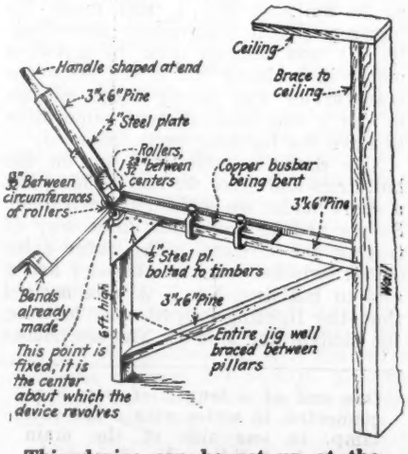
$$R=r\frac{(V-v)}{v}=r\left(\frac{V}{v}-\frac{v}{v}\right)=r\left(\frac{V}{v}-1\right)$$

In reality the two formulas are equivalent.—EDITORS.

Easily-Made Device for Bending Copper Busbar

THE method of bending copper busbars that is shown in the accompanying diagram is interesting in itself and may appeal to readers of INDUSTRIAL ENGINEER.

As can be seen in the accompanying diagram, the device consists of a 3-in. by 6-in. cross-member and a vertical upright of the same size, which are braced to the wall and floor. To reinforce the crosspiece and the upright, a ½-in. steel plate is bolted on each side of the timbers, as is shown in the diagram. In the corner of these two plates, a hole was drilled to receive a bolt carrying the roller over which the busbar is bent. In the diagram the plate is cut away so as to show the



This device can be set up at the place where the busbar is to be installed. The bender was used for bending bars ⅝ in. thick by 5 in. wide.

roller behind it. There are two rollers, each of which is 1½ in. in diameter. These are made from steel shafting. A hole was drilled through the axis of the roller to receive the bolts holding them in place. A handle made of 3-in. by 6-in. pine has two ½-in. steel plates bolted to one end, which carry the roller that applies the pressure to the top of the busbar. At the ends of these two plates are holes through which the bolt carrying the lower roller passes, thus forming the bearings for the handle to work in.

As can be seen from the diagram, the rollers are placed 1⅛ in. apart between the inside surfaces. This will permit bending copper busbar stock ⅜ in. thick. The stock that was handled was ⅜ in. thick by 5 in. wide and in lengths of approximately 8 ft. The dimensions given on the diagram are for a bender capable of handling this stock.

In operation the busbar is clamped to the crosspiece, as shown. As can be seen, there is a strip of wood on the back of the crosspiece, so as to keep the busbar square while bending. The part of the busbar that is to be bent is placed between the rollers and then by pulling down on the handle a bend up to 90 deg. may be made.

Oakland, Cal. S. H. SAMUELS.

Method of Determining Lighting Circuit Connections

THE accompanying diagram shows the method that was used in finding the relative lighting circuit connections in two buildings, about 50 ft. apart, supplied with single-phase, three-wire service which was brought in through long outside conduit runs. Building No. 1 was connected first and contained a motor operating at 220 volts and one lighting circuit of 110 volts. Building No. 2 was similarly wired and connected later, with the intention of having its lighting load balance that of building No. 1.

When connecting building No. 2, the electrician took it for granted that the outer wires to the main switch came "side for side" from the transformer, as in building No. 1, and made his lighting circuit connections accordingly. It was decided later to install a motor in building No. 2 and since the transformer was barely large enough to carry the load, it was imperative to have the lighting loads balanced.

The conduits were high up on the buildings and since we had nothing but a short ladder we could not reach them. So we had to find some other way of testing the circuits. The outer sides of the switches were numbered *1* and *2* and in building No. 1 it was noticed that the lighting circuit was between the neutral and side *2*. The electrician when connecting building No. 2 put the lighting circuit between the neutral and side *1*, as shown by the dotted line, which seemed logical enough.

We had a length of No. 14 wire handy; so we connected one end to side *2* of switch No. 1 and tested through a 220-volt lamp as shown for the opposite side of the circuit at switch No. 2. As was to be expected, we found the lighting circuit in building No. 2 was on the same side of the neutral as in building No. 1, as shown by the dotted connection. We changed the connection as shown by the solid line and then found the loads to be practically balanced.

This method of testing out the circuits was very simple and easy to apply and served its purpose well.

HENRY MULFORD.

Patchogue Electric Light Co.,
Patchogue, N. Y.

One end of a length of wire was connected, in series with a 220-volt lamp, to one side of the main switch in building No. 1 and the opposite side of the circuit found in building No. 2 by touching the other end of the wire in turn to each pole of the switch.

Practical Pointers on Charging Storage Batteries

MANY men are of the opinion that there has been very little, if any improvement in the manufacture of storage batteries for a number of years. But the construction of the batteries has changed, and one of the proofs of this can be found in the way in which batteries are now being charged.

The old way was to charge at a constant current, and the writer can recall when he was instructed that the proper way to charge a battery was to keep the current constant from the beginning of the charge until it was nearly ended.

This was done by raising the voltage of the generator from which the batteries were being charged, as the current in the batteries increased and their voltage became higher; by charging through resistance and cutting out more and more of this as the charging continued; or by the use of end cells which were cut out as the current dropped off.

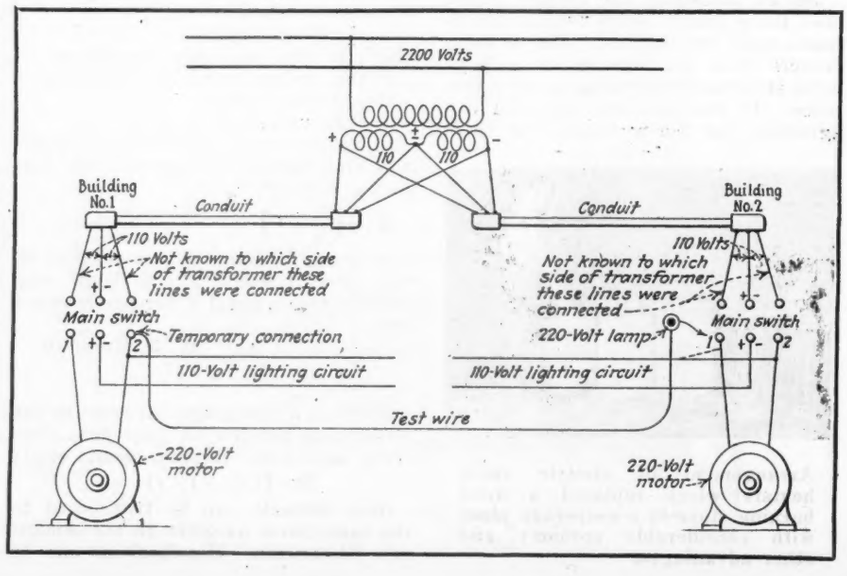
In those days it was believed that the best way to maintain a storage battery was to discharge it at a certain constant rate for a period of 8 hr., at which time the battery was supposed to be entirely discharged, or at least had been discharged as far as it was safe to go. Then the battery was put on charge and charged at the same constant rate for a period of 10 hr. The efficiency, in ampere-hours was considered to be about 80 per cent so that the 8-hr. discharge would exhaust the battery to the point where a 10-hr. charge would be required to restore it. After the 10-hr. charge at a constant rate it was thought best to continue the charge at a lower rate for several more hours, reducing the current from time to time in order to prevent gassing.

The reason for this care in charging and discharging the batteries was due principally to the fear that they would be badly injured, or at least have their life much reduced, by a higher rate of discharging. It was feared that the battery would be discharged too far; that the plates would become buckled; or that the active material would drop out of the plates.

In modern batteries, however, there is very little danger of these troubles occurring. Not only are the plates made better and stronger than the old ones, but separators are placed between the adjacent plates so that they cannot touch each other and become short-circuited even if there should be considerable distortion caused by buckling. There is much less chance of the active material dropping from the plates, and they are set up higher on longer feet so that more sediment can accumulate without the old danger of it rising so high as to short-circuit the plates.

On account of there being no fear of injuring the battery by charging faster than the old rate, a different method is now the generally accepted way of charging batteries. By this plan, instead of charging at a constant current and altering the voltage at the battery terminals so as to keep the current constant, the voltage is kept constant and the current is allowed to change. When the battery is first put on charge the current input is very high, but this soon slows down as the voltage of the battery rises.

So long as the current is not so great as to overheat the conductors leading



from the source of supply to the battery, or the terminal posts of the battery, the limiting amount of current can be considered as being that at which the battery begins to gas heavily, or else that which heats the electrolyte to a temperature of more than 110 deg. F.

If the battery is equipped with an ampere-hour meter set so as to show the number of ampere-hours that the battery has discharged, it is always safe to charge the battery at a rate which is not greater than the number of ampere-hours that have already been drawn from the battery, if the conductors and terminal posts will stand so high a charging rate.

As the voltage of the battery will increase as it is charged, there is no danger that the charging rate will be increased after the beginning of the charge unless the voltage of the supply circuit should also rise. Where that is constant, it is safe to say that the initial charging rate is not too high and then let the battery charge at that rate without having to watch the rate of charge closely One plan is to make the voltage of the charging circuit, at the battery terminals, equal to about 2.3 volts per cell of the battery being charged. At this rate the battery will become fully charged in a much shorter time than by the constant current method and the charge will automatically taper off to the proper finishing rate.

However, when a battery has been more or less completely discharged and the voltage correspondingly lowered, it will be found that such a high voltage applied to the terminals of the battery will give too high an initial charge. A safer way is to charge through a resistance which, although it will waste a little of the power passing through it, will limit the current in the beginning to a safe amount even if the battery should have been entirely discharged. On account of this resistance being in circuit, the voltage applied to the terminals of the battery and outside of the resistance should be equal to 2.45 volts, instead of 2.3 volts, per cell. This increase in the voltage will allow the battery to take a full charge, even though the resistance is there; while on the other hand, the resistance will insure that the charging rate will never be so high as to injure the battery or the conductors leading to it.

Westfield, N. J. G. H. McKELWAY.

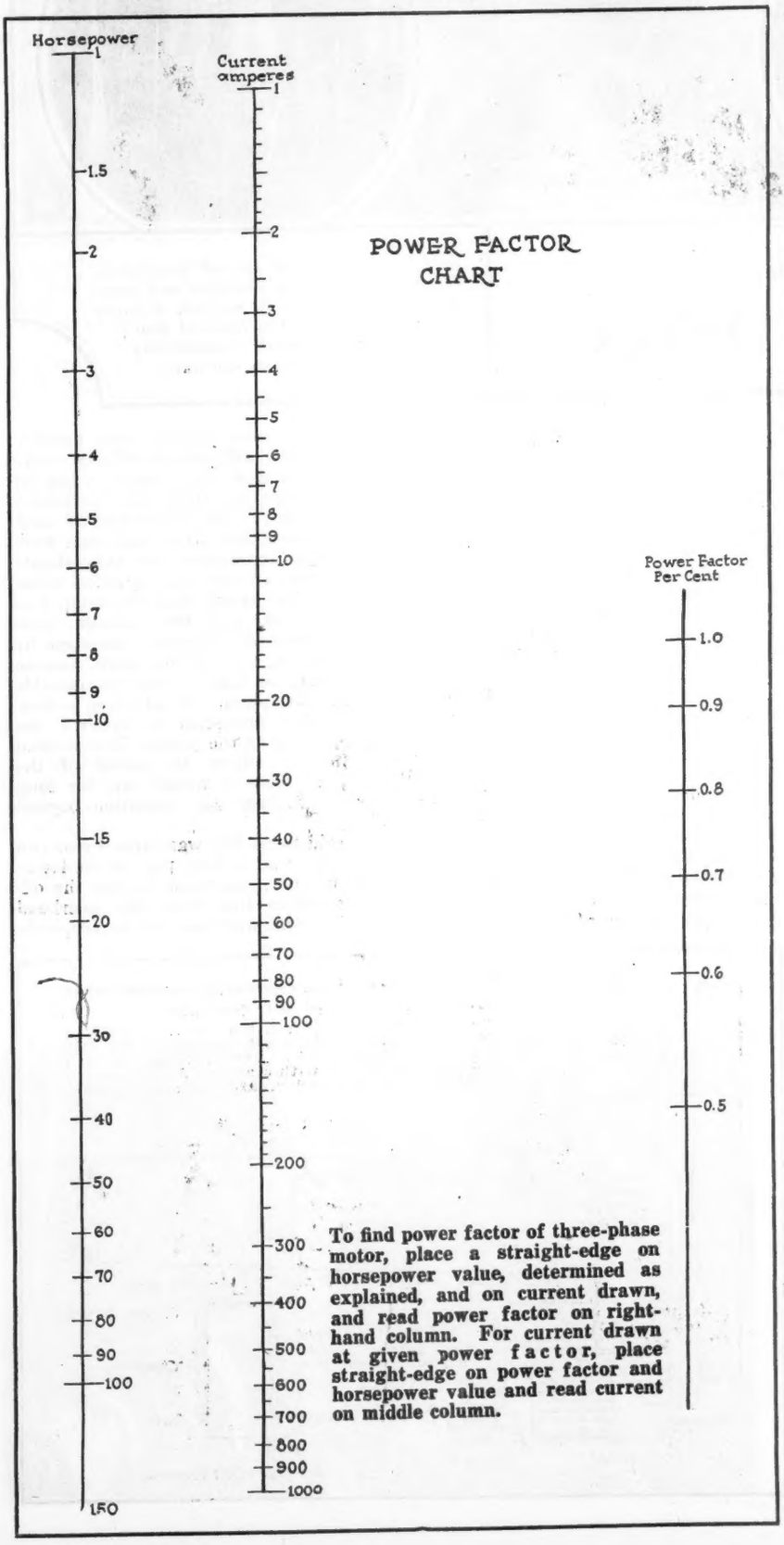

Horsepower
Current amperes
POWER FACTOR CHART
Power Factor Per Cent
1.0
0.9
0.8
0.7
0.6
0.5
To find power factor of three-phase motor, place a straight-edge on horsepower value, determined as explained, and on current drawn, and read power factor on right-hand column. For current drawn at given power factor, place straight-edge on power factor and horsepower value and read current on middle column.

Chart for Power Factor and Current of Three-Phase Motors

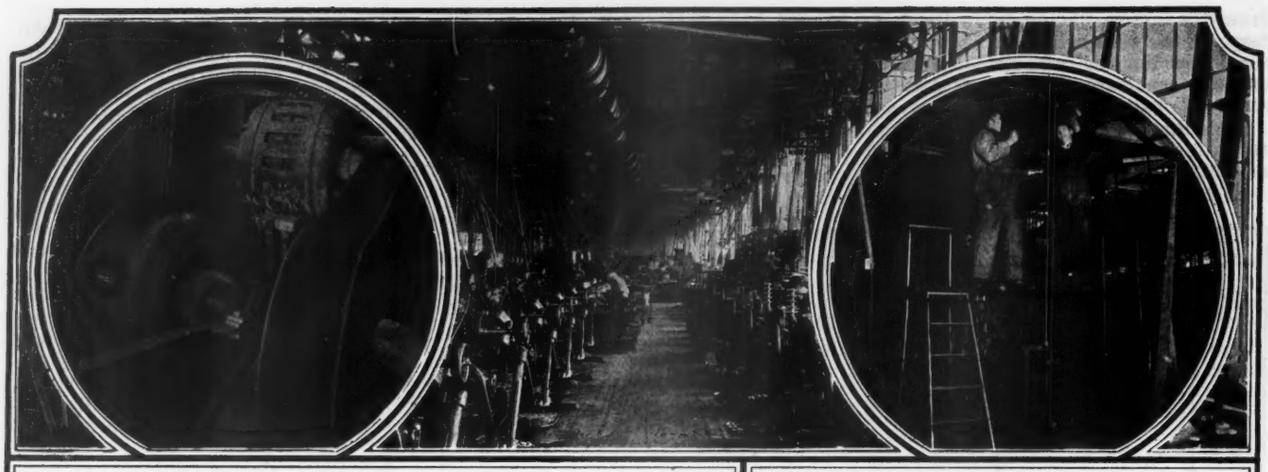
THE accompanying chart may be used to find either the power factor or the current of a three-phase, 220-volt induction motor. When using the chart to determine the full-load power factor, use the full-load current value stamped on the nameplate. For other than full-load values, use the corresponding horsepower values. Then, place a straight-edge so that it crosses the left-hand column at the proper horsepower and the middle column at the current drawn in amperes, and read the power factor on the right-hand column. To determine the current of a three-phase motor when the power factor and horsepower are known, place the straight-edge on the proper values in the right- and left-hand columns and read the current drawn on the middle column.

It should be noted that this chart may be used without corrections only for 220-volt motors. If it is desired to find the current for motors of other voltages the following corrections should be applied:

For 110 volts, multiply current by 2.
For 440 volts, divide current by 2.
For 550 volts divide by 2½.
For 1,100 volts, divide current by 5.
For 2,200 volts, divide current by 10.

CHAS. F. CAMERON.

Rock Springs, Wyo.



Mechanical Maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Modernizing Sets of Old-Type Gear Reductions With Oil Circulating System

IN A plant where a number of sets of reduction gears of a somewhat old type were used, their economical and efficient lubrication was a serious problem, as no provision was made for the circulation and recovery of oil. An oiler poured a given amount of oil regularly into the gear casing and emptied a catch-pan, attached to the casing, which caught the excess oil as it passed through the gears. Sometimes he forgot to empty the pan so that the oil ran all over the floor, and was wasted. The used oil was filtered and re-used in other parts of the plant.

On account of the difficulty of getting at the gears they were often neglected and serious trouble sometimes resulted, which was due to the gears freezing from lack of lubrication and attention. In order to improve and modernize the method of lubrication at a minimum cost, a circulating system was installed as shown in the accompanying drawing. This was an immediate success, both from the maintenance viewpoint and because of a noticeable decrease in operating costs, through the elimination of the oiler and in the amount of oil used.

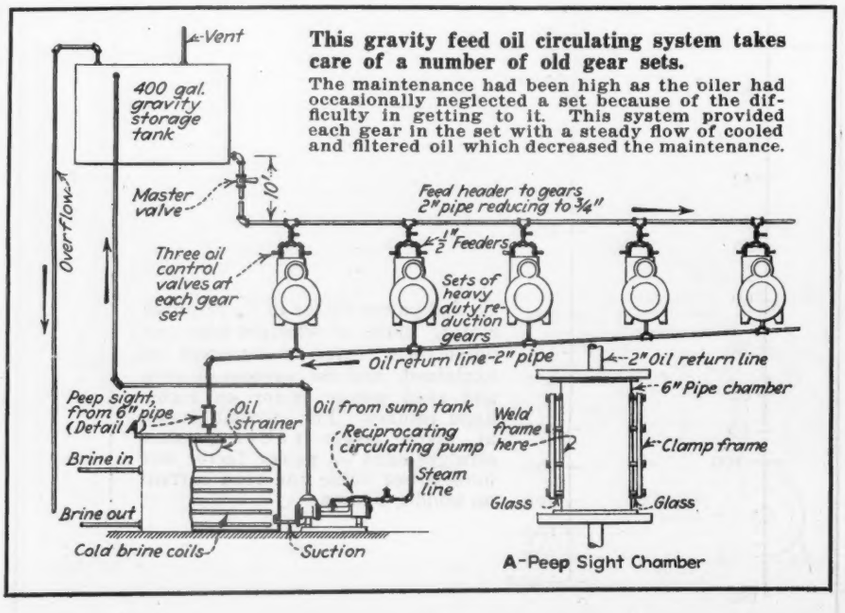
The 30-hp. reduction gears, giving a 20-to-1 ratio, which were connected through a pinion and gear to agitating paddles in tanks, were situated about 40 ft. above the floor. In order to get a gravity flow, it was necessary to elevate a 400-gal. storage tank about 10 ft. above the gears; fortunately the building was of sufficient height to permit this. A feed header nearly 200 ft. long was then run from the storage tank to the gears set farthest away. This header started with a 2-in. pipe and dropped by stages to a ¾-in. pipe.

From this header ½-in. feeder pipes, each with a master control valve, were run to each gear. These feeder pipes branched at the end through a tee so that the oil could be discharged into the two parts of the gear, with controlling valves in each of the separate lines. The oil drained from the gears flowed into a 2-in. return pipe which ran underneath the sets and sloped away from the furthest unit. Fortunately, the temperature of the building was hot enough all the time to prevent the oil from coagulating in the lines. This return line discharged into a sump tank on the ground floor. The returned oil was filtered through a strainer which consisted of a wire basket lined with flannel; the latter was detachable so that it could be cleaned.

Two small reciprocating pumps, that were not in use, were pressed into service to handle the oil from the sump to the gravity or storage tank. The pistons were grooved and fitted with a ring of babbitt which was cast and turned up. The pumps were hooked up so that one was always available as a spare in case of a breakdown.

At first some trouble was encountered in the adjustment of the pump speed. Because the pumps were of greater capacity than was necessary for this work they were run at such a slow speed that often shift men were under the impression that they should be running faster and speeded them up, with the result that the sump was pumped dry, and the storage tank would overflow. This was overcome by reducing the size of the steam pipe to the pump, so that it was not possible to race the pump. In addition, a float valve was connected to control the steam valve of the pump. It was then possible to adjust the speed of the pump so that it would run for long periods without any attention beyond oiling.

A cold brine line was tapped and run through a coil of 1-in. pipe in the lower part of the sump tank to cool the oil. An overflow line from the overhead gravity tank was run into a receptacle



This gravity feed oil circulating system takes care of a number of old gear sets.

The maintenance had been high as the oiler had occasionally neglected a set because of the difficulty in getting to it. This system provided each gear in the set with a steady flow of cooled and filtered oil which decreased the maintenance.

placed in a conspicuous place. The foreman on the shift watched this as it indicated whether any obstruction in the line prevented the oil from flowing out of the tank to the gears.

As the sump tank was a closed tank it was not possible to see the return flow from the main return header; so a peep chamber was made by running the line into a section of 6-in. pipe, with a piece cut out of two opposite sides, and a frame welded on with a piece of plate glass behind it and held in place by another frame and cap screws, as shown in the detail sketch. This was in line with a window in the daytime and a light at night so that the foreman could see the amount of oil being returned to the sump tank. As a result of this simple and inexpensive system, a cool, clean stream of lubricant was kept circulating through the gear units. This eliminated much heavy maintenance and increased the life and satisfactory operation of the gear units.

MAURICE C. COCKSHOTT.

Engineering Department,
Emsco Steel Products,
Los Angeles, Calif.

How Simple Changes in a Feed-Belt Drive Improved Operation

IN A specialty plant trouble was experienced on the drive for a Pratt & Whitney vertical surface grinder that was used only on one class of work. These machines come regularly with belt or motor drive and with two changes of feed to the table. This particular machine was belt driven, but had been equipped with a motor which drives through a chain; also, it was "plugged" so that the operator could use only the higher rate of feed. The change of feeds was made through a push rod connected to a clutch between two of the feed pulleys on one shaft.

This table feed required three 1¼-in. belts and six pulleys to obtain the one rate of feed; these belts transmitted power from the pulley on the first shaft, marked *Y*, in the illustration, and one on the shaft which runs directly to the feed mechanism, marked *X*. The machine was operated steadily all day and often at night and so the three belts required considerable attention. Also, due to the play in the parts controlling the clutch, it sometimes failed to feed.

This trouble with the clutch occurred at rare enough intervals for its cause to be forgotten or overlooked and the trouble attributed to some symptom that the latest operator thought he had discovered. In that way the clutch was responsible, at least once, for a half-day's delay while the repairman went over the other rather complicated mechanism before it was discovered that less than a minute's work on the clutch would fix it.

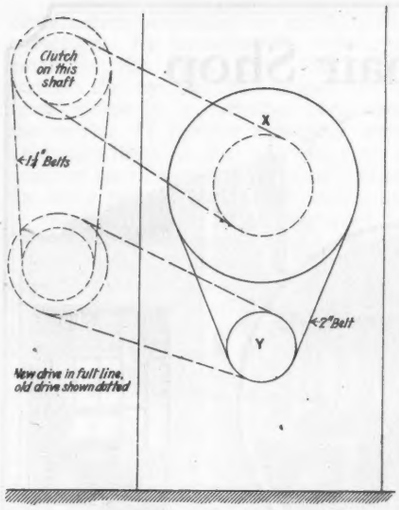
Finally, after one of these interruptions due to feed trouble, the master mechanic decided to alter the feed drive so that future trouble would be eliminated. As a result the machine now operates with two less feed belts and no clutch at all. The outline drawing shows the old and the new drives.

The diameter of the new driven pulley, *X*, is such that it turns at the same speed as its predecessor, although it is driven from the same small pulley, *Y*, directly beneath it. A 2-in. belt is now used which has nearly a half-circumference contact on the small pulley and its extra width gives it a longer wearing factor. The revised arrangement is much more simple and it is free from the former clutch trouble. The clutch was non-essential on the particular work done; however, to permit the use of a clutch was the only real excuse for the original triple-belt drive. The change more than paid for itself within a year.

A 5-hp., 1,800-r.p.m., alternating-current motor is mounted on the side of the machine pedestal and is connected to drive at the ratio of 3 to 2 by a Morse chain. Originally a step-cone pulley was belted from a countershaft, but this gave trouble; most of the lower step has been turned off to make room for the sprocket that takes its place. The driving side of the chain had to be the upper side, unfortunately, but in the seven years of its service it has never cost one cent in repairs or lost time.

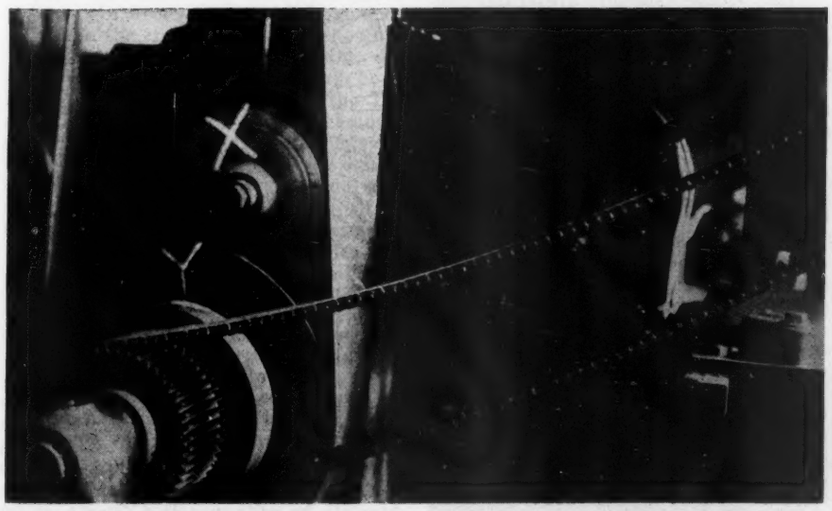
DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.



Three belts, six pulleys and a clutch were replaced by two pulleys and one belt.

Because this grinder was used on only one class of work it was possible to rearrange the drive and make it more direct. The original arrangement is shown by dotted lines in the sketch above; the improved drive is shown by solid lines.



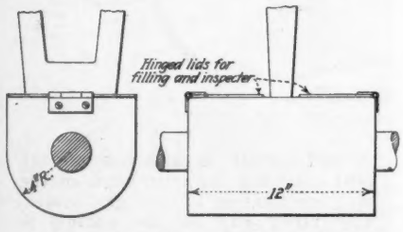
This illustration shows the drive after making the change.

Oversized Drip Pan Prevents Oil Dripping

SHAFTING in textile mills are prolific sources of trouble from dripping and thrown oil. Even grease, where used, thins on the hottest days of summer, and runs like oil. This may spoil thousands of dollars' worth of fabric before it is corrected.

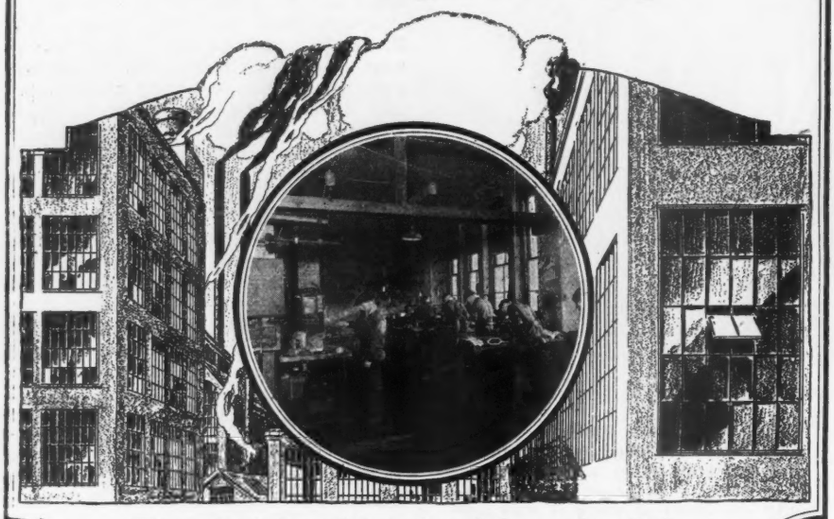
One large cotton goods mill has met the oil problem by completely enclosing the bearing of each hanger. For this it uses hundreds of pans of a standard size which can be fitted around the hanger on any size of shaft. The construction of this standard pan is shown in the accompanying sketch. This pan is more than a drip pan; it has sides, ends, and top and has a capacity of over a gallon of drippings. This oversize is a reserve against neglect and is large enough to enclose the bearings on the largest shafts.

The pans are made of 18 gage galvanized sheet metal with locked and soldered joints. Lids at the top may be opened on each side for inspection, filling, emptying, and cleaning. These pans are held to the hangers by attachment brackets on the inside.



The construction of this oil drip pan is standardized so that it fits all hanger bearings.

In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

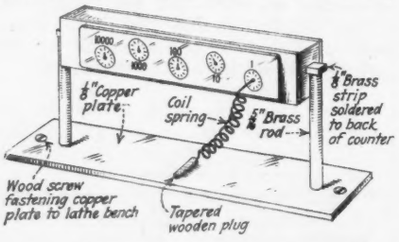
Easily-Made Device for Counting Turns When Winding Coils

IN THE April issue, page 204, Maurice M. Clement described a novel counter made from a speed indicator, for counting the turns on a coil. In our shop we use a counter made from the recording mechanism of an old gas meter and it works very well.

As will be seen from the illustration, a light coil spring was fastened to the post on which the unit dial hand of the meter was placed, and a wooden plug was fastened to the other end of the spring. A hole was drilled in the center of the spindle that holds the coil whose turns are to be counted and the plug was inserted in this hole. We riveted the counter to two brass rods and then cut a plate about 1½ in. wide and 6 in. long, from ⅛-in. copper. Two holes were drilled about 5 in. apart in this plate for the other ends of the rods to fit into, as shown The plate holds the counter rigid and by providing other plates at the different winding lathes we are able to use the same counter at all of them. The copper plates are fastened by screws to each lathe bench.

The counter has dials which indicate units, tens, hundreds, thousands and ten thousands. By noting the reading when starting to wind a coil, it is an easy matter to determine at any time how many turns have been wound on by subtracting the first reading from the reading shown when stopped.

Peoria, Ill. GEO. D. RINGNESS.


⅛"Copper plate
Coil spring
⅛"Brass rod
⅛"Brass strip soldered to back of counter
Wood screw fastening copper plate to lathe bench
Tapered wooden plug

A coil spring is attached to the post carrying the unit hand on the dial mechanism of the gas meter. The other end of the spring is fastened to a wooden plug, which is inserted in the spindle of the winding lath.

Repairing Broken Drills by Use of Brass Sleeve

BREAKAGE of small drills is an annoying accident and if the stock is low or the drill is a special size, some delay may be occasioned. A broken drill can, however, be restored to service in a short time and at almost no expense, by making a brass sleeve into which the two broken ends of the drill can be soldered or sweated.

This sleeve should preferably be seamless and for this purpose seamless brass tubing, or solid rod with a drilled hole of the proper size to accommodate the broken drill, should be used. It is advisable to tin carefully the broken ends for a short distance. When tinning the ends, care must be taken not to overheat the drill and spoil the temper. If possible, the inside of the brass sleeve should also be tinned. When the broken ends of the drill are inserted in the sleeve, it is then an easy matter to sweat the ends to the sleeve by heating the latter carefully.

This same procedure has been used to prevent the breaking of new drills where the extended section from the jaws of the chuck makes it liable to fracture. The point where the break is most likely to occur is the junction of the flutes and the shank. A brass tube sweated or soldered on to a new drill is a very simple and effective reinforcement which is readily applied and overcomes to a marked extent the tendency to fracture.

Washington, D. C. G. A. LUERS.

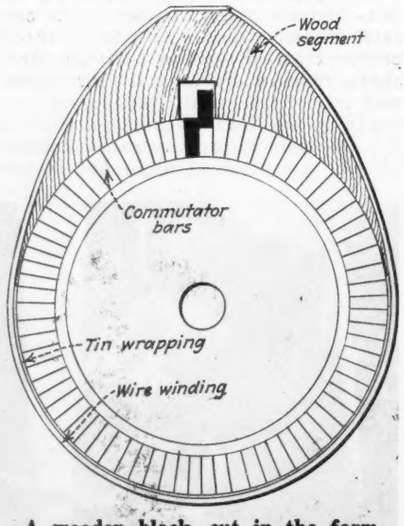
How to Make Simple Clamp for Replacing Commutator Bars

IN AN Eastern industrial plant, there are a number of Northern d.c. motors ranging from 5- to 15-hp. rating, that have been in use over 25 years. The plant repair man handles most of the maintenance and one of his occasional jobs is the replacing of commutator bars which have been tested and found shorted, and so have to be removed. It is only an occasional job, as has been said, and the man has very little equipment to work with—still he keeps the maintenance cost in that plant down to a very low figure.

He has an interesting way of keeping the commutator assembly in shape while replacing some of the bars. Before loosening the V-rings, he puts on a sort of clamp that prevents the bars from separating. This clamp is as efficient as it is simple, and consists of a piece of tin, some wire and a piece of wood, as shown in the illustration.

The wood block is cut from a piece of maple or oak somewhat over an inch in thickness, and is shaped in the form of a segment whose inner circle fits the commutator just half-way around. This segment is fastened to the commutator with wire and on the opposite half the piece of tin is laid double to prevent the wire from grooving the face of the commutator.

The wood segment has a slot cut in it, as shown, that is the width of one or two bars (whatever number have to come out) and deep enough to allow them to be lifted clear of their neighbors. This slot does not prevent the segment from holding down these neighboring bars, which is its sole pur-



A wooden block, cut in the form of a segment, and containing a slot the width of one or two bars, is fastened to the commutator by wrapping wire around it. A strip of tin keeps the bars not covered by the segment from being damaged.

pose. For different commutator diameters, different segments are needed, but these are inexpensive to make and answer the purpose very well.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Layout of Lighting System and Equipment in Repair Shop

DEMANDS on a commercial repair shop are more varied and perhaps more severe than in the case of many industrial plant repair shops. The work coming to it ranges all the way from the repair of vacuum cleaner and other very small motors to rewinding the largest motors which it is practicable to transport for this purpose. For this reason close attention to details in laying out the equipment and the illuminating system is essential.

When we planned our new shop, the writer's past experience as an illuminating engineer naturally caused him to see to it that the lighting, both natural and artificial, was fully adequate from the standpoint of the latest developments in the lighting art. It is well known that our ideas have changed considerably in the past ten years regarding the amount of light which is proper for industrial operations. Evidence of the practical "dollars-and-cents" importance of both increase of quantity and an improvement in quality of illumination, has been rapidly piling up.

For daylight illumination, it was not feasible to provide windows on more than one side and in a small portion of another side, but at these places the maximum amount of window area obtainable was installed, as is shown in the illustration.

In a shop where armature winding is an important part of the work, good diffusion of light is important. That is, light must come from many directions. This is but another way of saying that freedom from shadows is essential. Again, as most of the winding work is on the stators of induction motors, the lighting should be such as to give a minimum of shadow in the stators in which the coils are being placed. In order to provide this good diffusion, the entire interior of the shop was given a coat of white paint, applied by an air brush. A small portable air brush outfit made by the Decora Manufacturing Co., Richmond, Calif., was used in this work. This air brush outfit is a part of the shop equipment, as it is used for cleaning and painting motors and also for finishing lighting fixtures in another department.

Painting the shop white was an important factor in getting well diffused light, both by night and by day, as the reflection from the ceiling and walls helps to eliminate annoying shadows.

As will be seen from the illustrations, the lighting equipment consists of bare bowl-enameled lamps. The omission of reflectors is not due to carelessness or a desire to save first cost, but to deliberate design. In a low-ceilinged shop of this kind, with walls and ceiling white, a much better quality of diffused illumination is obtained by omitting the reflectors. By omitting the reflectors, much of the light from the lamps strikes the ceilings and upper walls, from which it is reflected back onto the work. If opaque reflectors were used, the light at any one point on a winding bench would come largely from the lamp and reflector units which are of relatively small area compared to the reflecting surfaces offered by the upper walls and ceiling. The result would be much sharper shadows and less comfortable conditions as regards glare. As to the glare from the bare bowl-enameled lamps as compared to bowl-enameled lamps in steel reflectors, it is obvious that the brightest objects within the range of vision in either case are the tips or bowls of the lamp bulbs and these are, if anything, less bright on the bare lamps. If opaque reflectors were used, the ceiling would be considerably darkened and the contrast of the reflectors against the darker ceiling would offer an element of glare.

What has been said must not be taken as an argument against the use of reflectors. Their use is advisable in a large number of cases where, on account of high or dark-colored ceilings, it is not feasible to obtain much diffused reflection from the upper walls and ceiling, but it should be emphasized that the blind following of one common type of construction sometimes leads to unnecessary expense and inferior results.

As a general proposition for an armature shop, indirect lighting is the best. In the case of this shop, however, indirect lighting was not as necessary as in larger shops, and conditions were not so favorable as though the ceiling were plain and not cut up by joists. The conditions of work in the shop are not such that the light sources are within the range of vision steadily for any considerable length of time. The work benches, lathe, shears and coil winding machine are all so situated that the men do not face light sources when at work. The armature winding benches are in the center of the room, but when winding stators, a man's head is usually inclined so that the lamps are out of the field of vision. The room shown is about 16 ft. by 33 ft. and is lighted by eight 200-watt bowl-enameled lamps. The illumination on the working planes is from 15 to 18 foot-candles.

The equipment of the shop is shown in the illustration. Trucks can be backed in one end of the shop and motors picked up by the hoist which runs on an I-beam the length of the shop. The power driven machines consist of one lathe, one coil winding machine and an emery and buffing wheel.

The old-fashioned testing board with open knife switches and various exposed live contacts was eliminated in conformity with the safety regulations now in force in California. While exposed live parts are, of course, permitted in electrical testing shops and laboratories under the rules of the California Industrial Accident Commission, it was felt that the common testing operations in a motor repair shop did not necessarily call for more hazardous construction than used in any other industry.

The motor and testing circuits are controlled by the standard externally operated switches now required in all industrial plant work in California. For testing purposes, two- and three-pole receptacles of various capacities are provided and controlled by externally-operated switches.

We use a portable electric oven for baking coils, so that it can be moved to any convenient point in the room. Ordinarily, it is placed at one end in line with the hoist. It is connected by a three-conductor plug and cord to the three-phase power circuit. The oven measures 20 in. by 36 in. by 32 in. and has two Cutler-Hammer flat, air-heating, 600-watt elements.

J. R. CRAVATH.
President,
Pioneer Electric Co.,
Richmond, Calif.

Bare, bowl-enameled. 200-watt lamps furnish the light in this shop. Note the enclosed, externally-operated switches on the testing board at the right.

Industrial Uses of Structural Slate

(*Continued from page 535*)

the pressure when the drill is about to break through, to prevent a large scale from breaking away at the back. Whenever possible it is well to finish a hole by drilling in from the back as soon as the point gets through, as doing so prevents pieces breaking out.

Another use of slate is for special table tops, as in tanneries, for making tanks and vats for dye works, and tanneries, and so on. The particular advantages of slate as a material for these purposes are that it is non-absorptive, is not affected by the liquors, and also because it has a very low co-efficient of expansion, so that the joints do not work loose and break the cement which fastens the slabs together, as would be the case if the material expanded and contracted with changes of temperature. Slate is also commonly used for the tops of work tables used in the manufacture of candy, because the candy does not stick to the surface. Also, the surface can be easily cleaned or scraped and will remain smooth and even.

Editor's Note: Acknowledgement is made to the Structural State Co., Pen Argyl, Pa., for the photographs and information used in this article.

Visual Record for Motor Failures

(*Continued from page 518*)

check on the work of each of his maintenance foremen. The foreman knows this and consequently does his best to keep the tabs off his cards.

When a red tab appears on a card an investigation is made at once. Possibly the record on the card may show that bearing or oil trouble is the cause of the failures. In this case roller bearings are substituted for the sleeve bearings. In some cases it is necessary to take a load test on the motor by means of a graphic meter to determine what steps should be taken to eliminate the cause of the failures.

Since the system is easily understood and can be quickly grasped by anyone, it provides a good indicator by which the electrical superintendent can acquaint the plant manager with conditions in the electrical department. The necessity for new or improved power-drive equipment, more maintenance men, and the like, can be quickly verified by the graphic record shown by the system.

The advantages of this system may be summed up in the following:

(1) It enables the electrical superintendent to keep his hand on the pulse of his department. His attention is quickly attracted to the troublesome motors of the 3,000 under his care and steps can be taken to eradicate the trouble at once.

(2) Since the cards are filed by divisions, the electrical superintendent knows exactly what foreman to hold responsible for an undue number of failures. This acts as an incentive to the foreman to make a good showing.

(3) The system provides the electrical superintendent with a way of quickly showing his superior what the operating conditions are in his department, and will help to justify his request for more or better equipment, or more men.

Groundwork Before Erecting Lineshaft

(*Continued from page 523*)

to the concrete ceiling. For this purpose we use Brohard expanded shells. We have found that ⅝-in. bolts with the proper size of expanded shell will hold any footing except possibly for the larger sizes of shafts, which are seldom supported from the ceiling. To install these, holes are drilled into the ceiling, the shells driven into place and then the plank footing is attached by screwing up the bolts, which expands the shell in the concrete and gives a firm grip. A hole 4 in. deep with the proper size shell to take a ⅝-bolt is satisfactory.

Figs. 5 and 8 show an installation of a shaft on a concrete ceiling in a paint mill. The same method was used to hold up an I-beam for a monorail.

Whenever a building is wired and the power is available we use a Syntron electric hammer for drilling into the concrete. If power is not available, a man with a hammer and a star drill does the work. Sometimes it is necessary to drill holes entirely through the concrete, countersink the bolt heads, and patch up the floor.

A concrete ceiling probably furnishes the most satisfactory foundation for supporting a lineshaft as it transmits comparatively little vibration through from the floor above. Also, the deflection is comparatively slight. With these two factors eliminated the shaft is not likely to get out of alignment easily. However, it is always good practice to go over a shaft and check up the alignment after it has been in operation a short time and at frequent periods later.

There is still another problem of installation which occasionally comes up and is usually not easy to solve. A recent case of this kind was met in extending a lineshaft down through the center of a room with a high ceiling where there was nothing upon which to support the shaft hangers or footings. A few special columns consisting of extra-heavy 6-in. H-beams were erected by sinking one end in the concrete floor and fastening the other to the ceiling construction. Two parallel lines of extra-heavy, 7-in. ship channels were bolted crosswise to these H-beams. Wall brackets were used which had special projections or feet cast on them to fit into the two channels. Pillow blocks on the wall bracket support the shaft.

Sufficient allowance, however, had not been made for the severe service under which it operated and also more machines were added to the line than had been considered at first. As a result the shaft was too small and vibrated due to the high speed at which it operated and the "whip" which was transmitted back to it from the centrifugal machines which it drives. This was overcome by inserting additional brackets and pillow blocks midway between those already installed. These support the shaft on 4-ft. spacing instead of the standard 8-ft. spacing, but would not have been necessary if a slightly larger diameter shaft had been specified by the user. However, this was the first installation of such a large battery of centrifugal machines and the effect of the whip was unknown. This is an SKF ball-bearing installation operating at 600 r.p.m.

As mentioned at the beginning of this article, experience is a very important factor in lineshaft installation work. It is quite difficult, in some cases, to tell just exactly how a special installation will stand up until it is tried out.

EDITORS NOTE: All of the illustrations shown in connection with this article are of installations made under the supervision of Mr. Trimm in his work as millwright superintendent for the Chicago Pulley & Shafting Co.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Electric Locomotive for Industrial Service—Book 250 is a 56-page catalog of trolley, storage battery, third rail, combination battery and trolley, and combination battery and third rail electric locomotives for industrial service. This book is well illustrated with a large variety of installations as well as a detailed description of the various types of units.—Goodman Mfg. Co., 4840 Halsted St., Chicago, Ill.

Flexible Couplings—Circulars announce a new flexible coupling known as the Sykes Universal shaft coupling. This consists of hubs fitted on the shaft with lugs projecting outward and a sleeve cast in halves with internal lugs fitted over this. Connection between the two is made by balls resting in races or grooves formed in these lugs. Claim is made that this coupling will take care of a limit of angularity of 5 deg. and a limit of offset of 4 per cent of the maximum bore. This coupling is at present manufactured in shaft sizes from ¾ in. to 8 in.—Farrell Foundry & Machine Co., Buffalo, N. Y.

Charging Plugs and Receptacles—A 72-page Bulletin, 38, under the above title covers the line of Anderson single-pole, double-pole, and three-pole battery charging plugs and receptacles for use in the charging of storage batteries for a wide range of commercial and industrial purposes. —Albert & J. M. Anderson Mfg. Co., 289-305 A St., Boston, Mass.

Tapered Roller Bearings — Announcement is made of an improvement and refinement in the design of the roll and in the shape of the Timken tapered roller bearing.—The Timken Roller Bearing Co., Canton, Ohio.

Portable Blower—A circular describes the new Sturtevant Big Midget portable blower, which is designed to be used for blowing dust out of motors, generators and all kinds of machinery. This blower is held in the hand and the blast directed through a nozzle; it is also furnished as a stationary unit.—B. F. Sturtevant Co., Hyde Park, Boston, Mass.

Polyphase Transformer Test Connection Diagrams—Pocket-sized Bulletin 2048, under the above title, shows diagrams of test connections to be used on Pittsburgh polyphase transformers. — Pittsburgh Transformer Co., Pittsburgh, Pa.

Recording Pyrometers—A circular describes the Brown new design, single and duplex (two-record) recording pyrometers, multiple-record recorders, which can be arranged to make from one to six simultaneous records in distinctive colors on the same chart, and the multiple-duplex recorder, which will make from two to six simultaneous records on each half of a duplex chart.—The Brown Instrument Co., Wayne & Windrim Aves., Philadelphia, Pa.

Carbon Brushes—Catalog 7 illustrates, describes and prices the various types of carbon brushes for generators, motors and all stationary machines. The different shunt connections are listed according to capacity and priced separately.—Le Valley Vitae Carbon Brush Co., 3608 Grand Central Terminal, New York City.

Magnetic Clutches—Publication P-11 devotes 16 pages to illustrations and descriptions of many new uses of magnetic clutches on synchronous motor drives, particularly where the starting duty is severe, as in the cement, flour, paper and steel mill industries. — The Cutler-Hammer Mfg. Co., Milwaukee, Wis.

Conduit Fittings—A 21½-in.x32¾-in. wall hanger, which is attractively printed in colors, illustrates the various types of Unitlets—steel conduit fittings.—Appleton Electric Co., 1718 Wellington Ave., Chicago, Ill.

Welding Rods—A 28-page, pocket-size book entitled, "Properties of Steel Filler Rods for Gas and Electric Welding," discusses the properties of iron and steel filler rods and the effect of these properties, or the lack of them, upon the welding. The different types of Weldite rods, their specifications, analysis, and the types of work they are to be used on, are also included.—Chicago Steel & Wire Co., 103rd St. and Torrence Ave., Chicago, Ill.

Flexible Power Unit—A circular describes the Superba electric flexible power unit which consists of a motor driving a flexible shaft which operates scratch brushes, grinders, buffers, drills and other types of light revolving apparatus. — Sirianni & Trumbettas Mfg. Co., 6-8-10 Brown St., Carbondale, Pa.

Capacitors—A 24-page bulletin GEA-77 describes the value of capacitors for power factor correction, gives details as to their operation, location, and so on, and includes a number of illustrations in the form of charts, diagrams, tables and photographs of installations.—General Electric Co., Schenectady, N. Y.

Paint for Galvanized Iron—A folder describes Galvanum paint which is intended to be applied directly to galvanized iron without the previous use of an acid wash or primer. This paint is made in all colors, including black and white. Other special paints for specific industrial purposes are also listed.—Goheen Corp. of New Jersey, Newark, N. J.

Industrial Electric Heating Equipment —An 8-page catalog illustrates and describes a variety of special and standard electrical heating units for heating water and other liquids and compounds, air heaters, ovens and special heaters. Special attention is called to an electric pipe heater which can be mounted on pipes to keep them from freezing in cold weather.—Hynes & Cox Electric Corp., 406 N. Pearl St., Albany, N. Y.

Electric Hoists—A 28-page catalog illustrates and describes the constructions as well as numerous applications of the Low-Hed electric hoist, which is so constructed as to require only a small amount of head room below the monorail or other support. —American Engineering Co., Philadelphia, Pa.

Safety Ladders and Scaffolds—Circulars give the prices of and illustrate a line of safety extension ladders which can be used for industrial painting, millwrighting, and other miscellaneous industrial jobs. Bulletin 56 describes the Junior safety scaffold which is supported by steel wire ropes for painting, tuck pointing and other maintenance or repair work on the outside of buildings.—The Patent Scaffold Co., 1420-44 Center St., Chicago, Ill.

Standardized Bus Supports and Outdoor Substations—Announcement is made of a new net price list on standardized outdoor substations. A 38-page bulletin, 31-B, contains 119 illustrations giving detailed information on high-tension bus supports for voltages up to and including 120 kv. These supports are of standardized unit type with 21,000 combinations for standard, heavy-duty and extra heavy-duty service and are adjustable at top and bottom.—Delta-Star Electric Co., 2400 Fulton St., Chicago, Ill.

Speed Reducers—Bulletin 10-25 illustrates, describes briefly, and shows a few installations of the latest types of Philadelphia worm gear and spur gear reducers.—Philadelphia Gear Works, Richmond and Tioga Sts., Philadelphia, Pa.

Portable Carbide Lights—A booklet entitled "The Milburn Light" illustrates and describes the various types of portable and semi-portable carbide lights for lighting yards, mines, quarries and so on for night construction or other outdoor night work.—The Alexander Milburn Co., Baltimore, Md.

Underground Cable Boxes—Bulletin 25 describes and illustrates a line of underground cable boxes for use in manholes or handholes, for interconnecting, sectionalizing, fusing or plain splicing of underground electric cables.—G. & W. Electric Specialty Co., 7780 Dante Ave., Chicago, Ill.

Ball Bearing Motors—Bulletin 25 describes the various types of Baldor electric motors, which are made in capacities of ½ to 10-hp., squirrel cage, polyphase; 1/6 to 5 hp., repulsion-induction, single phase; and 1/6 to 2 hp., direct current. Specifications and special applications are also given.—Baldor Electric Co., 4351-55 Duncan Ave., St. Louis, Mo.

Distant Dial Meters—Bulletin 69 describes the Sangamo distant dial meter which is used with watt-hour meters for duplicating at a convenient location the reading of the meter

register, for totalizing the revolutions or strokes of engines, generators or other machines, or for summing on a single dial the total registration of a group of watt-hour meters. These distant dial meters are made in two types, for operation on direct current and on alternating current.—Sangamo Electric Co., Springfield, Ill.

Automatic Control of Planers Direct Connected to Motors—Publication C-14 bearing the above title, gives the advantages of such control equipment, describes the principal parts of the equipment, its operation and gives details concerning it.—Cutler-Hammer Mfg. Co., Milwaukee, Wis.

Meter Service Devices—A circular folder describes the ease of installation of the Noark service system for entrance meters.—The Johns-Pratt Co., Hartford, Conn.

High-Speed Induction Motors and Frequency Changers—A 27-page, paper-bound bulletin 41521-B, bearing the above title, is well illustrated with photographs, diagrams and tables and presents a complete line of motors, alternators and frequency changers adaptable for application on modern, high-speed woodworking machines and other forms of machine tools requiring high-speed drives.—General Electric Co., Schenectady, N. Y.

Twin-Type Graphic Meter—Bulletin 425 describes a twin-type graphic meter which is provided with two charts so that any two items may be recorded simultaneously. These can be furnished in any combination of ammeter, voltmeter, wattmeter, kva.-meter, power factor meter, frequency meter, speed, pressure or vacuum recorder, condenser meter or service recorder and the two units can be alike or different. The two charts are driven by one chart-driving mechanism so that the record is made simultaneously of the two quantities.—The Esterline-Angus Co., Indianapolis, Ind.

Magnetic Counter—A circular describes magnetic counters which are operated by electromagnets and used under conditions where it is desirable that the counter be placed at some distance from the machine on which the count is to be taken. In this way a number of counters can be grouped together in a central or other convenient place. This counter is operated by direct current only.—The Veeder Mfg. Co., Hartford, Conn.

Panelboard Practice—A 48-page catalog describes the Superior switchboards for power and lighting, panelboards and cabinets for lighting and feeder distribution panels of dead or live front types. Diagrams, prices and applications are shown.—The Superior Switchboard & Devices Co., Canton, Ohio.

Expulsion Type Fusible Primary Cutout—Circular 65120 describes the Type E, Form A, Catalog No. 260-277, 100-amp., 7,500-volt fusible primary cutout.—General Electric Co., Schenectady, N. Y.

Roofing Reference Series—A series of five booklets contains architects and engineers construction service and design information on Barrett built-up roofs under the following five headings: I, Flat Roof Specifications; II, Steep Roof Specifications; III, Roof Flashing System; IV, Roof Drainage System; V, Dampproofing and Waterproofing. Each of these contain about 36 pages and are illustrated with drawings which give information to those interested in building or re-building roofs.—The Barrett Co., 40 Rector St., New York City.

Electrical Conduit—A folder entitled, "Facts Concerning Electrical Conduit," discusses the qualities required in good electrical conduit and describes the qualifications of Buckeye conduit and Realflex flexible steel armor cable.—The Youngstown Sheet & Tube Co., Youngstown, Ohio.

Rotary Shears—Catalog 60 describes the different types and sizes of rotary shares which are made to handle all gages of sheet metal up to and including 1 in. sheet steel. These are made in seven sizes. Shears for the lighter gages of metal may be used in many sheet metal shops of industrial plants for making safeguards, ventilating ducts and other miscellaneous plant work.—The Quickwork Co., St. Marys, Ohio.

Power Transmission Equipment—A new catalog under the above heading describes the Rex set collars and Cinch (compression) couplings for line-shafts, pillow blocks, journal bearings, post boxes, shaft hangers, extra heavy duty takeups, square or spiral jaw clutches, sprockets and chains.—Chain Belt Co., Milwaukee, Wis.

Flexible Couplings—A folder illustrates and gives dimensions and prices of five types of flexible couplings which Foote Bros. recommend and sell for use in connection with I.X.L. speed reducer units.—Foote Bros. Gear & Machine Co., 215 N. Curtis St., Chicago, Ill.

Welding Electrodes—A 16-page booklet under the above title describes the characteristics and application of the three types of General Electric electrodes, designated as Types A, B and C, for use on cast iron, steel and on overhead welding. Brief instructions are given covering the use of each type.—General Electric Co., Schenectady, N. Y.

Electric Hoists—Form 118 illustrates and describes the Type R Roeper electric hoist which is made in capacities ranging from 500 to 6,000 lb.—Roeper Crane & Hoist Works, Inc., 1720-1738 N. 10th St., Reading, Pa.

Pressure Regulators—Bulletin 1033-B describes the E. C. & M. automatic pressure regulator which is used with motor-driven pressure systems for automatically regulating the pressure of water, air or other liquids or gases. Cushion tanks to take care of fluctuating pressure are also described.—The Electric Controller & Mfg. Co., Cleveland, Ohio.

Friction Clutch—A circular describes the Hilliard friction clutches and cut-off couplings which are made for both high- and low-speed operation. The pressure is applied through a rack and gear worm-thread movement.—The Hilliard Clutch & Machinery Co., Elmira, N. Y.

Electric Glue Pot—A circular describes the Red Crown glue pot with a snap action thermostat which automatically maintains the contents at the correct temperature and helps to eliminate fire risk. This pot is made in 1-qt., 2-qt., and 4-qt. sizes, for 110 and 220 volts. Other electrically-heated pots for melting other materials, such as lead, babbitt, pitch, wax, and so on, are also listed.—Hynes & Cox Electric Corp., 406 N. Pearl St., Albany, N. Y.

Synchronous Timer—Circular 67781, Class 16, describes the construction and operation of the Type MF-2 synchronous timer for indicating the time in which a device, such as a relay, performs an operation that includes the opening and closing of an electrical contact.—General Electric Co., Schenectady, N. Y.

Distribution Apparatus—A catalog describes the dead-front and live-front switchboards, panelboard switches and other special equipment, as well as steel cabinets, pull boxes, battery-charging rheostats and so on, manufactured by this company.—The Leonard Electric Mfg. Co., 3907 Perkins Ave., Cleveland, Ohio.

Stainless Steel—A 20-page booklet entitled "Stainless in Industry" explains the characteristics of stainless steel and shows many of the different possibilities for its use in various lines of industry.—The American Stainless Steel Co., Commonwealth Bldg., Pittsburgh, Pa.

Valve Control—Bulletin 103-29-B describes the Cory-Recony valve control units which permit of remote control through a separate power panel in which all circuits are opened and closed. Electrical braking permits seating with full power. This control is designed for use on 2- to 60-in. valves under varying pressure and temperature conditions.—Chas. Cory & Son, Inc., 183-7 Varick St., New York City.

Portable Saw—A folder describes the South Bend portable woodworker, Model A-25, which is a motor-driven circular saw mounted on a stand with casters to make it portable. A ¾-hp. motor drives an 8-in. crosscut or rip saw. An exhaust fan and bag to collect the sawdust make it possible to use this machine in places where dust and dirt must be avoided.—Koontz Bros., Electric Co., South Bend, Ind.

Electric Hoists—A circular describes the Moto monorail hoist of ¼- to 5-tons capacity, which is so designed that any stock motor of standard make may be installed; thus a plant may maintain a program of standardized motorization.—Drake Electric Hoist Co., Friendship, N. Y.

Repulsion-Induction Motors—A folder describes the R. & M. Type RA repulsion-induction motors rated from ½ to 7½ hp. inclusive. These are made to operate at 60, 50, 40 and 25 cycles on 110 or 220 volts.—The Robbins & Myers Co., Springfield, Ohio.

Waterproofing and Dampproofing—Specification Book A, the first of a set of six, gives new and revised specifications for waterproofing mass concrete, cement stucco, brick, masonry, and also describes various dampproofing paints, oil proofings and quick-set for cement. Each specification is complete with full information on how to use, quantity required and is illustrated with sketches.—The Truscon Laboratories, Detroit, Mich.